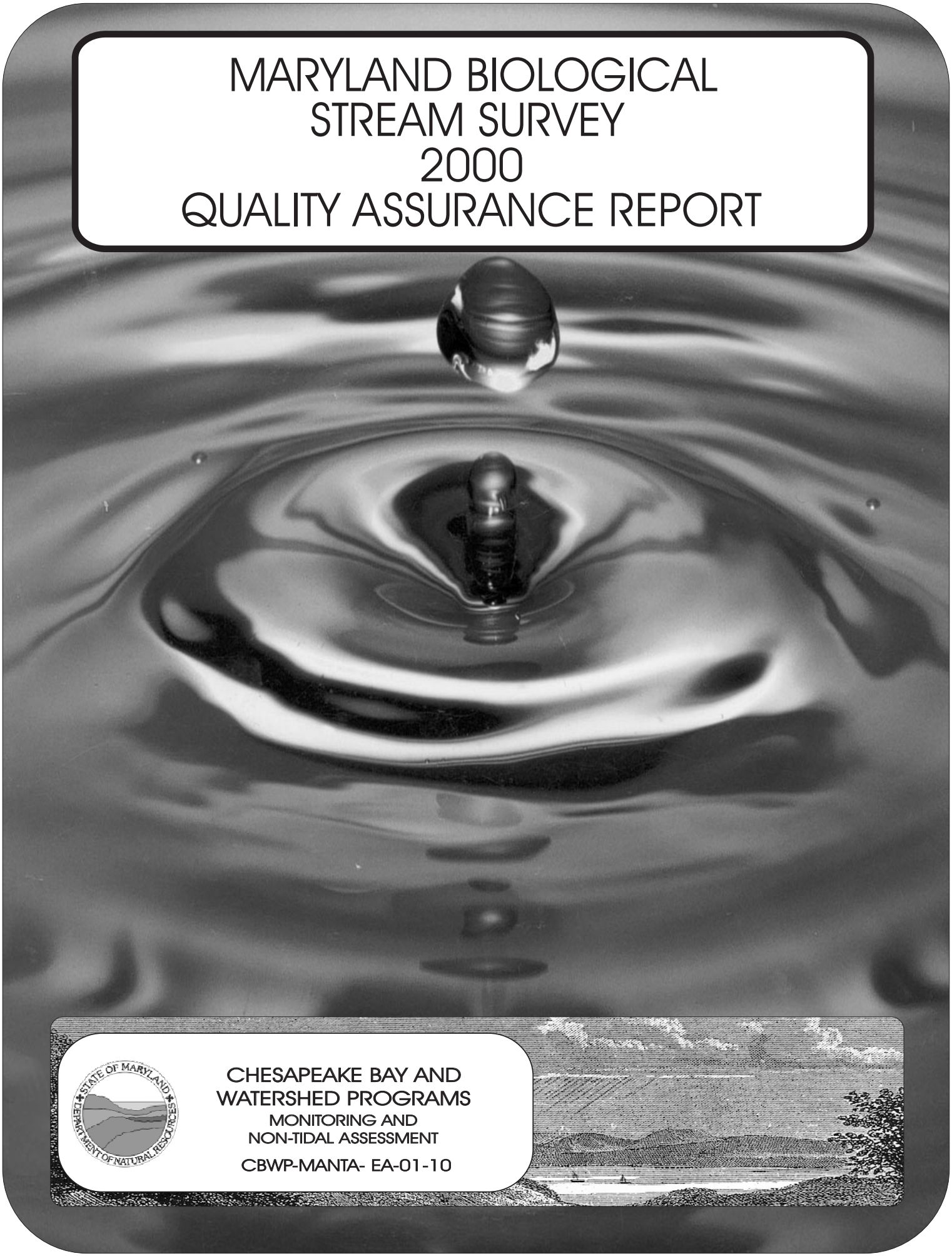
MARYLAND BIOLOGICAL STREAM SURVEY 2000 QUALITY ASSURANCE REPORT



CHESAPEAKE BAY AND WATERSHED PROGRAMS

MONITORING AND NON-TIDAL ASSESSMENT

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Maryland Biological Stream Survey

2000

Quality Assurance Report

Prepared for

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FOREWORD

This report, *Maryland Biological Stream Survey 2000, Quality Assurance Report*, was prepared by Versar, Inc. and supports the Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS) under the direction of the MBSS QC Officer, Mr. Paul Kazyak of the Monitoring and Non-tidal Assessment Division. Versar's work and this report were prepared under Maryland's Power Plant Research Program (Contract No. K00B0200109 to Versar, Inc.). A major goal of the MBSS is to assess the ecological condition of Maryland's streams, with a particular focus on biological resources, but also evaluating water chemistry and physical habitat. This annual report presents results of the Quality Assurance/Quality Control (QA/QC) activities of the 2000 MBSS.

ACKNOWLEDGMENTS

The MBSS 2000 QA Report has been a cooperative effort among several agencies and consultants. We at Versar wish to thank Ron Klauda and Paul Kazyak from the Maryland Department of Natural Resources (DNR) for directing the program and supporting Versar in preparing this report as well as for comments received on a previous draft. We would also like to thank the University of Maryland's Appalachian Laboratory (AL) which provided the quality assurance data for water quality, Dr. Rich Raesly of Frostburg State University who provided taxonomic verifications of voucher fish specimens, and the MBSS field crews (both Maryland DNR and AL) for providing us with sampling records and answering questions. Versar managed data, conducted statistical analyses, and prepared this report. The success of the project resulted from the strong efforts of all these groups. We particularly thank the key individuals listed below for their contributions:

Versar
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1 INTRODUCTION

1.1 BACKGROUND

The purpose of this report is to document the Quality Assurance/Quality Control (QA/QC) activities associated with the 2000 Maryland Biological Stream Survey (MBSS), a monitoring program conducted by the Maryland Department of Natural Resources (DNR). QA/QC activities have been an integral part of the MBSS since its inception in 1993, but until now an annual summary of QA/QC activities has not been compiled. MBSS data is now being used for a wide array of resource management and regulatory decisionmaking; this report provides users with a convenient means to evaluate MBSS data quality and provide feedback to improve the program.

The year 2000 was the first year of five years of sampling planned for Round Two of the MBSS program. The primary objectives of the MBSS are to:

- assess the current status of biological resources in Maryland's non-tidal streams;
- investigate trends in these biological resources;
- quantify the extent to which acidic deposition is affecting biological resources in the state;
- examine which other water chemistry, physical habitat, and land use factors are important in explaining the current status of biological resources in streams;
- provide a statewide inventory of stream biota; and
- target future local-scale assessments and mitigation measures needed to restore degraded or threatened biological resources.

To achieve these objectives, the Maryland Department of Natural Resources (DNR) conducts field studies that involve the collection of biological, physical habitat, and water quality data, as well as information on anthropogenic stressors. Biological variables are used to determine the ecological condition of streams within a watershed. Habitat variables are used to describe the condition of the aquatic and riparian environment. Water quality and anthropogenic stressor data are used to describe and identify potential sources of impairment affecting the stream.

The Quality Assurance (QA) program for the MBSS was designed (1) to ensure that data are of known and sufficient quality to meet the primary objectives of the MBSS and (2) to provide estimates of the sources of variance associated with the individual variables being measured. The major components of the QA program include the following:

- assignment of responsibility and accountability to key personnel;
- development of Data Quality Objectives (DQOs);
- codification of project protocols and guidelines;
- thorough investigator training;
- comprehensive documentation of procedures and results;
- integrated field and laboratory data management;
- auditing and evaluation of data acquisition;
- assessment of QA results for data interpretation and program refinement; and
- QA and peer review of reports.

In addition to documenting the QA activities of the 2000 MBSS sampling, this report evaluates the QA results which include comparisons of replicate sample and independent field audit data. The report also evaluates QA steps taken throughout the site selection, data collection, data management, and reporting phases. The recommendations of this QA report will be used to identify ways to improve and maintain the quality of the MBSS.

1.2 ROADMAP TO THIS REPORT

This report presents the activities and results of the 2000 QA program and includes 12 chapters and 4 appendices. Chapter 2 identifies the key personnel and their responsibilities during the MBSS 2000. Chapter 3 discusses data quality objectives. Chapter 4 presents the survey design, sample selection, landowner permissions, site selection, and GIS meta data. Chapter 5 references the standard operating

procedures for sampling other program activities. Chapter 6 summarizes the training requirements for all field personnel. Chapter 7 presents the documentation procedures of the program. Chapter 8 discusses data acquisition audits. Chapter 9 summarizes the results of the data quality assessment with sections on water quality sampling, benthic sampling, fish sampling, herpetofauna sampling, aquatic vegetation sampling, and habitat sampling. Chapter 10 includes information on reporting and Chapter 11 concludes the report by providing recommendations. Chapter 12 contains References. Appendices include (A) notes recorded by the MBSS QC Officer, (B) the Appalachian Laboratory's *Summary of Quality Assurance/Quality Control Results from Spring 2000 Water Chemistry Analysis for the Maryland Biological Stream Survey*, (C) benthic taxa lists for sites with duplicate field samples, (D) benthic taxa lists for sites with duplicate laboratory samples, and (E) the number of individual fish species samples compared to the number retained as fish voucher specimens.

2 KEY PERSONNEL

To ensure that adequate responsibility and accountability for MBSS data are maintained, an organizational structure defining the responsibilities for MBSS key personnel was prepared. Because several organizations are involved in implementing the MBSS, adherence to the chain of authority and responsibility is especially important to the MBSS QA program. A number of personnel report directly to the Project Officer, including the Training Officer, the Quality Control Officer (QC Officer), the Field Crew Supervisor for each organization involved in field sampling, and the Data Management and Analysis Officer (DM Officer). The responsibilities of each of these personnel are described below:

- Project Officer (Paul Kazyak) - The MBSS Project Officer has overall responsibility for successful completion of the MBSS. Specific duties of the Project Officer include selection of project staff, direction and approval of training activities, contractor oversight, liaison with the public and resource agencies, document review, and peer review solicitation.

- Training Officer (Paul Kazyak) - The Training Officer is responsible for training all field sampling personnel. At the direction of the Project Officer, the Training Officer coordinates with the QC Officer and the Field Crew Supervisor to implement remedial or additional training deemed necessary between MBSS field sampling periods.

- Quality Control Officer (Paul Kazyak) - The QC Officer is responsible for implementation of all aspects of the MBSS QA program, including inspection of field crews, data validation, taxonomic verification, site confirmation, calibration and maintenance of equipment, adherence to established protocols, and prompt identification of necessary remedial or corrective actions. The QC Officer is also responsible for oversight of laboratory QA managers to ensure that all MBSS laboratory activities meet MBSS QA/QC requirements.

- Data Management and Analysis Officer (Martin Hurd) - The DM Officer is responsible for receiving, reviewing, and signing off on the original data sheets, as well as supervising and verifying data entry.

- Field Crew Supervisor (Scott Stranko, Ray Morgan) - The Field Crew Supervisor is responsible for day-to-day communication with Crew Leaders, coordination and approval of sampling schedules and itineraries, and other activities designated by the Project Officer.

- Crew Leader (Scott Stranko, Anthony Prochaska, Matthew Kline) - The Crew Leaders are responsible for crew safety, sample scheduling, equipment maintenance and calibration, and performance of all sample collection activities in accordance with procedures and QA/QC requirements specified in the MBSS sampling manual.

- Field Sampling Crew - Members of the sampling crew are responsible for carrying out the instructions of the Crew Leader and informing the Crew Leader of any unsafe conditions, equipment failures, or other problems observed that could jeopardize the health and safety of the crew or the quality of sample collections. Crew members for 2000 included: Marty Hurd, Jay Killian, Dave Baxter, Bill Rodney, Karl Routzahn, Chris Millard, Brenda Morgan, Miguel Dode, Christine Rozycki, Derek Wiley, Jamie Welch, Josh Fair, and Greg Turner.

3 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are statements that specify the desired quality of data; they provide a rigorous means of determining whether the data have the certainty needed to support specific decisions. Data quality is described as the precision, accuracy, representativeness, completeness, comparability, and sensitivity of data (U.S. EPA 1995). One goal of the MBSS QA program is to develop measurement quality objectives for each major quantitative variable in the survey. The development of measurement quality objectives for variables with small sample sizes will require additional data from future years of Round Two of the MBSS.

The organization and development of the MBSS have led to the incorporation of procedures that are likely to attain high accuracy, representativeness, completeness, comparability, and sensitivity. These aspects of data quality are evaluated qualitatively throughout the report. In addition, this report quantitatively evaluates the precision of the MBSS data. Precision is the degree of agreement among repeated measurements of the same variable (U.S. EPA 1995) and is calculated in this report using the Relative Percent Difference (RPD) when there are only 2 duplicate samples or Relative Standard Deviation (RSD) when there are 3 or more replicate samples.

3.1 MBSS DECISIONMAKING CONTEXT

The establishment of DQOs is necessary to specify how good MBSS data must be to support decisionmaking, including the level of uncertainty that the state is willing to accept. It is important to note that DQOs for the MBSS are target values for data quality and are not necessarily criteria for the acceptance or rejection of data.

The original impetus behind the MBSS was to examine the effects of acidic deposition on stream biota. Since that time, additional uses of MBSS data have been identified. For example, MBSS data were used in the most recent statewide water quality inventory (Clean Water Act 305(b) list) and to identify impaired waters. Therefore, the DQOs for the MBSS will likely continue to evolve. In a future QA/QC report, results of the first round of the MBSS will be used to refine DQOs within this new decisionmaking context.

3.2 THE DECISIONS TO BE MADE

Data from the MBSS will be used to support management decisions such as the following:

- a determination of the extent and magnitude of acidic deposition effects on stream biota in Maryland;
- an evaluation of the degree to which the flowing, non-tidal waters of Maryland have balanced, indigenous populations of biota as specified in the Clean Water Act;
- a determination as to whether specific waters of the state require further investigation of stressor sources and impacts;
- prioritization of watersheds for protection, restoration and/or enhancement;
- a determination as to which anthropogenic stressors need to receive more intensive management and enforcement activities;
- further development of validated biological indices for evaluation and monitoring of impacts from anthropogenic stresses; and
- listing and protection of rare aquatic species.

In future years, it is likely that MBSS data will contribute to a determination as to whether existing fishery management practices are adequate to protect important fish stocks.

3.3 POPULATION OF INTEREST

The current MBSS population of interest includes all non-tidal, 4th-order and smaller stream reaches of the State of Maryland, based on a reach file digitized from 1:100,000-scale USGS topographic maps. Exceptions within this population are non-wadable impoundments and impoundments that substantially alter the riverine nature of the reach.

3.4 DATA COLLECTED AND THEIR UNCERTAINTY

The data obtained by the MBSS to address the management decisions described above include biological, water quality, and physical habitat data. Specifically, ecological indices and population estimates are derived to depict the water quality, physical habitat quality, biological integrity, and fishability of Maryland streams and rivers.

Two important sources of uncertainty in these data are precision and bias. Precision and bias relate to the amount of random and systematic error, respectively, and are determined through the use of replication, performance evaluation samples of known composition, and confirmatory analyses by experts. At present, results from the initial round of the MBSS have not been fully analyzed to define uncertainty, although some analysis of variability in fish and benthic indices of biotic integrity have been done (Roth et al. 2001b). Therefore, uncertainty limits have not yet been defined for most variables measured by the MBSS. When this analysis is complete, it will be presented in a future QA/QC document.

4 SURVEY DESIGN AND SITE LOCATIONS

Obtaining high quality data depends as much on selecting the proper sites to sample as it does on effectively sampling them. The MBSS includes in its QA/QC activities considerations related to the sample frame of Maryland streams, survey design, sample selection, and obtaining landowner permissions. Each of these entails certain assumptions about how well the sampled sites represent the true population of interest–Maryland's 4th-order and smaller, non-tidal streams.

4.1 REACH FILE DESIGNATION

To improve the resolution of MBSS base maps for Round Two sampling (started in 2000), the decision was made to use a 1:100,000-scale map rather than the 1:250,000-scale map used in Round One (1995-1997) (Southerland et al. 2000). The base data source was USGS Digital Line Graphs (DLGs; http://www.edc.usgs.gov/glis/hyper/guide/100Kdlgfig/states/MD.html) derived from 30- by 60-minute quadrangle maps. This 1:100,000-scale reach file is consistent with the National Hydrography Dataset (NHD), an EPA product designed to incorporate both the EPA Reach Files (RF3) and the USGS DLGs. The EPA RF3 file was also developed from these USGS maps, but contains reported errors, including missing stream reaches. It was anticipated that the use of the original USGS maps would circumvent many of the errors associated with the RF3. Another advantage of using this smaller scale reach file was that it would allow for better characterization of headwater stream features, which is important in determining the status of acidified streams and fish populations in headwaters.

In the USGS stream reach files, reaches are not assigned a Strahler stream order, a key parameter needed for the MBSS site selection process. Therefore, this variable had to be attributed manually. Examination of hard-copy topographic maps from Maryland and adjacent states aided in determining the direction of stream flow when it could not be determined from the USGS maps alone. Attributes from the USGS files such as lakes, large rivers, ditches, and canals were also used when the designation of stream order was not straightforward. For example, in order to properly designate flow within a watershed, stream connections were made between streams that were connected by what USGS designated as a canal. Also, in braided third-order streams such as those in the Zekiah Swamp watershed, each braid was designated as a third-order stream and counted toward the total number of third-order stream miles, even though in practice all braids of a stream are sampled when an MBSS site falls on any single mapped braid. During spring, braids are often connected because of high flows. All stream order designations were reviewed by a second GIS analyst for continuity within and between watersheds, but is possible that some errors were introduced during this process. We believe that this method of attributing stream order to the sample frame was likely as accurate as an automated process (which was unavailable), though not as cost effective. For more detailed documentation concerning MBSS reach file development see Brindley (2001).

Another potential error in the sample frame is the assignment of an MBSS site below the head-of-tide. A tidal boundary was developed using existing knowledge of the head-of-tide, but, in 2000, two segments selected for sampling were actually located below the head-of-tide. In each case, the designated sampling locations were near, but slightly below the head-of-tide. In these instances, no sampling was conducted and a replacement site was selected. An additional problem that may exist in the 1:100,000-scale reach file is the possibility that non-tidal waters extend further downstream than delineated on the reach file, resulting in an underestimate of non-tidal species richness in some basins. However, given the small number of segments selected for sampling during 1995-1997 that fell into this zone - on the order of two sites (assuming a similar level of error for overestimating the tidal boundary as for underestimating it) - it is unlikely that population estimates for basins would change substantially if the head-of-tide was perfectly defined and no error was associated with physically locating the segments identified for sampling.

Due to inherent discrepancies between any map and the real world, errors similar to those encountered using the Round One 1995-1997 sample frame (1:250,000) may also occur in Round Two (1:100,000). Although the Round Two digitized stream reach file accurately represented Year 2000 streams at the vast majority of sites, a small number (approximately 5%) of MBSS 2000 sites were moved from the original GIS-generated coordinate location once field crews assessed the actual condition of the site. New coordinates were noted from field global positioning system (GPS) readings, recorded on the data sheets, and transferred to the MBSS database. These discrepancies may have resulted from changes in the stream channel, since the development of the USGS reach file, either from anthropogenic or natural causes.

More generally, it should be emphasized that the 1:100,000-scale reach file is only one representation of "real world" streams. Many Maryland counties use the even finer scale 1:24,000 topographic map, which would include considerably more smaller streams than the 1:100,000-scale maps used by the MBSS. For example, in Seneca Creek, located in Montgomery County, streams on the 1:100,000-scale map and the 1:24,000-scale map overlap approximately 60% of the time. Thirty-eight percent of streams are located only on the 1:24,000-scale map, while the remaining 2% are found only on the 1:100,000-scale map. These differences are attributed primarily to the inclusion of smaller streams on the 1:24,000 map, but also to the greater sinuosity of streams depicted on the 1:24,000 map.

Although the use of the 1:100,000-scale map has increased the number of stream miles in the population of streams potentially sampled by the MBSS, there are still many smaller, headwater streams being excluded from sampling. The use of a 1:24,000-scale map may be considered for the third round of MBSS sampling.

4.2 SURVEY DESIGN

For the 2000-2004 MBSS, the decision was made to focus on stream condition at a smaller, watershed scale, rather than the larger drainage basins scale used in the first round of sampling (Southerland et al. 2000). The State of Maryland contains 138 8-digit watersheds, as defined by Maryland DNR and Department of the Environment (MDE). Four of these are not relevant to the MBSS, because they are located in the Chesapeake Bay or have no non-tidal stream miles. Locating the required number of sites (minimum of 10) in each of the remaining watersheds would be prohibitive given the time frame and resources available to the MBSS. Therefore, the smallest 8-digit watersheds were grouped together into "combined" Primary Sampling Units (PSUs) based on proximity and similar land uses. This process resulted in a total of 85 PSUs (one of which contains the 4 completely tidal watersheds), of which 30 are "combined" PSUs. For a PSU map and sampling schedule, see the MBSS 2000 Report (Roth et al. 2001a).

Once the PSUs were combined, 10 sites were randomly selected in each PSU. Although this sample design allows for the collection of data in all sampleable 8-digit watersheds, the use of combined PSUs means that not every 8-digit watershed will contain the 10 sites needed for precise estimates. Therefore, conditions in these watersheds can only be described as part of the combined PSUs (which may include widely different conditions). While grouping these watersheds to facilitate sampling eliminates many of them from consideration in the State's proposed biocriteria framework at the 8-digit level (which requires 10 sites), individual site results can be used in the 12-digit subwatershed analysis.

4.3 SAMPLE SITE SELECTION

For the 2000-2004 MBSS, a FORTRAN program was used to pick random sites within each PSU. These sites were mapped and examined by eye by a GIS analyst to ensure that all sites fell on streams, that no sites fell on a confluence, and that no sites were within 75 meters of another site. Ten sites were allocated to the majority of PSUs, although the 21 PSUs with the most stream miles received additional sites in proportion to the number of stream miles they contained. Sites were also allocated based on the proportion of first- and second-order streams to the third- and fourth-order streams where possible. It was understood that Round Two's greater focus on small streams (Round One's sampling effort was allocated equally to first-, second-, and third-order streams statewide), would likely result in less precise estimates of many gamefish populations (which are concentrated in larger streams).

4.4 LANDOWNER PERMISSIONS

Obtaining permission to assess private properties is critical to a random survey such as the MBSS. For the 2000 MBSS, more than 600 landowners were contacted to request permission to access field sites. As part of the process, landowners were identified using county tax maps and subsequently contacted by mail or by telephone. A handwritten record was maintained for each landowner contacted, listing the site number, landowner name and phone number or address, parcel number, and date/time of the contact. This information was entered as a relational database in Microsoft Access. A copy of this record was taken into the field at the time of field sampling and proved to be highly useful on the few occasions when field crews were approached by landowners who did not recall giving permission and co-owners (e.g., spouses) who were not aware that permission had been granted.

Problems in the landowner permission process usually involved inaccuracies either in the tax maps or in the telephone directories used to identify phone numbers of potential landowners, resulting in the contacting of the wrong person. For example, in Town Creek PSU, the field crew believed that they were on state-owned land based on

the tax map, when in fact they were on private land that the owner did not want sampled. Other problems included:

- The sale of the property since the generation of the tax maps, with no way to contact the new owners;
- Deceased owners listed in the tax maps with no further point of contact;
- Incorrect/old phone numbers; and
- Letters returned to sender.

4.4.1 Landowner Permission Rates

For the MBSS 2000 sampling, the overall permission success rate was 67%. Eight percent of responses received were permission denials, while 25% of attempted contacts did not respond. Of the landowners that did respond, 90% granted permission while 10% did not. Table 4-1 gives a breakdown of permission rates by PSU. In one PSU, Brighton Dam, refusals and non-contacts resulted in the majority of sites being sampled on public lands, raising a concern that results might be biased for that PSU, as public lands generally have more forested land and have streams in better condition than private lands. In fact, a broad range of ecological conditions were observed at the Brighton Dam sites sampled. Because this condition occurred in only one PSU containing only 10 sites, it is unlikely that a significant bias was introduced into statewide estimates of stream condition by the landowner permission process.

It was noted that public reluctance to allow the field crews on private property appears to have increased since the 1995-1997 field seasons. Not only did the people contacting the landowners have more refusals and nonresponses (combined) than in the past, but the field crews reportedly had to deal with more uncooperative landowners while sampling. This may be a result of increased restrictions for farmers concerning nutrient loading to the Bay and of a general increasing distrust of the government. If this trend continues throughout the second round of sampling, especially among the farmers on Eastern Shore, a bias could be introduced into the survey's estimates of stream condition.

Table 4-1. Landowner permission success rates for Primary Sampling Units (PSUs) sampled in the 2000 MBSS

PSU	Number of Stream Segments Targeted as Potential Sample Sites	Success Rate	No Response	Denial Rate
Casselman River	26	69%	31%	0%
Town Creek	20	80%	15%	5%
Fifteen Mile Creek	20	90%	10%	0%
Potomac River WA Co/Marsh Run/Tonoloway/Little Tonoloway	24	84%	16%	0%
Upper Monocacy River	34	64%	25%	1%
Mattawoman Creek	18	61%	33%	6%
Nanjemoy Creek	20	55%	45%	0%
St. Mary's River	18	72%	17%	11%
Brighton Dam	26	62%	26%	12%
Little Patuxent River	26	81%	18%	1%
South Branch Patapsco River	22	60%	32%	8%
Liberty Reservoir	30	83%	7%	0%
Patapsco River Lower North Branch	28	71%	25%	4%
Prettyboy Reservoir	24	63%	25%	12%
Aberdeen Proving Ground/Swan Creek	20	65%	15%	20%
Corsica River/Southeast Creek	20	74%	16%	10%
Upper Choptank	26	54%	23%	23%
Lower Wicomico River/Monie Bay/Wicomico Creek/Wicomico River Head	25	56%	32%	12%
TOTAL	474	67%	25%	8%

4.5 SITE LOCATIONS

In several cases, the proximity of streams to each other (especially near confluences), coupled with the locational error of the GPS receiver resulted in difficulty determining which stream was selected for sampling. In all cases, careful examination of tax maps, the MBSS stream system map, and topographic maps enabled Crew Leaders to resolve the issue in the field. To date, no records have been kept to identify the sites where resolution was necessary, but the proportion of these sites was small (approximately two sites per year).

4.6 GIS META DATA

To report upstream catchment area and land use for the MBSS 2000 sites, catchment boundaries were digitized by DNR using ArcView 3.1a software and 1:24,000-scale USGS quad maps. The catchments were digitized up to the applicable Maryland 12-digit watershed linework to reduce digitizing error and sliver polygons. This process also resulted in an increased standardization for nested or adjacent watersheds. The digitized catchments were then overlaid on Multi-Resolution Landscape Characteristics (MRLC) data Version 040998 (April 9, 1998) land classifications to develop land use statistics for each MBSS site. For more information concerning the MRLC, see the MRLC homepage at http://www.epa.gov/mrlc/.

5 SAMPLING METHODS

The heart of the MBSS QA program is the set of standard sampling methods developed by the Project Officer, Paul Kazyak. These standard operating procedures contribute to the collection of high quality data by being comprehensive for, representative of, and sensitive to changes in the stream conditions being sampled. The comparability, precision, and accuracy of the data are best served by codifying these procedures in the *Maryland Biological Stream Survey Sampling Manual* (which is updated regularly; see Kazyak 2000, 2001). This manual provides health and safety guidelines, outlines QA/QC requirements, documents equipment needs and trip preparation requirements, in addition to presenting sampling and data management procedures for site selection, determination of sampleability, temperature logger deployment and retrieval, and water quality, benthic macroinvertebrates, fish, herpetofauna, and physical habitat data acquisition.

6 TRAINING REQUIREMENTS

An important aspect of the MBSS QA program is the mandatory training of field personnel that is conducted prior to sampling. The goal of the training is to ensure consistent implementation of required procedures and attainment of a minimum level of technical competency by each MBSS participant. This standardized training helps to maximize the comparability of data among field crews. In addition to crew training, Crew Leaders are given additional instruction and guidance to maximize consistency in decision-making. To meet the program's QA objectives for training, crew leaders must successfully pass examinations administered during annual training.

For personnel involved in sampling during the spring index period, training includes water quality and benthic macroinvertebrate sampling using MBSS procedures (Kazyak 2001). For personnel involved in sampling during the summer index period, training includes fish and herpetofauna sampling, habitat assessment, and a laboratory examination concerning the identification of Maryland fishes and herpetofauna.

During the summer training for the MBSS 2000 sampling, all three Field Crew Leaders received high scores on both the fish (77.5 to 97.5%) and herpetofauna identification tests. Table 6-1 lists the three field crews and the number of people passing the taxonomy tests for each crew.

Table 6-1. MBSS 2000 field crews and numbers passing fish and herpetofauna taxonomy tests (85 to 97.5%) with a minimum score of 90% correct

	Number Passing	
Field Crew	**Fish**	**Herpetofauna**
Appalachian Lab	1 (20%)	0 (0%)
DNR Crew 1	1* (17%)	2* (33%)
DNR Crew 2	2* (40%)	2 (40%)

* Number includes crew leader.

7 DOCUMENTATION

To ensure scientific credibility, study repeatability, and cost effectiveness, the MBSS attempts to document all project activities. These activities include the following:

- landowner contacts;
- adherence to sampling protocols;
- equipment calibration;
- field sampling;
- chain-of-custody sheets;
- review of data sheets;
- extensive notes on field audits;
- information management;
- data quality assessment;
- data analyses; and
- interpretation of data.

To minimize the possibility that needed documentation or data are not recorded, standardized forms and on-site verification of form completeness by supervisory personnel are employed as part of the MBSS. These documentation procedures and requirements are more fully described in the MBSS Sampling Manual (Kazyak 2000 for year 2000 sampling).

7.1 FIELD INFORMATION MANAGEMENT

To facilitate data recording during inclement weather, MBSS data sheets are printed on waterproof paper. Backup copies of all field data sheets are made prior to submittal to the Data Management Officer.

To ensure that all field data for the MBSS are collected and recorded in a usable manner, data are recorded in the units specified on the MBSS data sheets. Recorded data are reviewed at the sampling site and the Crew Leader reviews and initials all data sheets prior to departure from the site. Legible copies of data sheets are provided to the DM Officer on an approximately bi-weekly basis during sampling.

During the 2000 sampling period, the above data recording procedures were followed and no data sheets were lost. However, there were some cases when the DM Officer did not receive copies of the data sheets within two weeks.

7.2 DATA ENTRY

Once the Crew Leaders have submitted legible copies of data sheets to the DM Officer, the QC Officer examines the sheets and records potential errors, documents and corrects discrepancies, and periodically alerts Crew Leaders to prevent similar errors in the future (see QC Notes in Appendix A). In the 2000 MBSS, errors that were noted and corrected included (but were not limited to) the following:

- Spelling errors for fish and herpetofauna species;
- Incorrect or misspelled stream names;
- Smears on data sheets and illegible handwriting;
- Inconsistencies in the listing of riparian buffer vegetation types;
- Meter calibrations not signed for; and
- Blank spaces on data sheets.

To verify that all data collected at a sampling segment were complete and acceptable, data entry of all data sheets occurred after data sheets were received and reviewed by the DM Officer. Data entry was accomplished using entry screens designed in Microsoft Access to emulate the data sheet format (Figure 7-1). Whenever possible, QA/QC checks were embedded into data entry screens to ensure validity of data. With the exception of water chemistry, all MBSS data (including benthic lab identifications) were independently entered into two databases and compared using a computer program as a quality-control procedure. Differences between the two databases were resolved using original data sheets or through discussions with Field Crew Leaders. Documentation of changes was maintained for most editing activities.

Automated review procedures such as range checks, frequency distribution of coded variables, and other internal consistency checks were designed by Versar, Inc. and employed for data entry verification.

For the 2000 MBSS, all data discrepancies were documented and resolved by DNR and Versar staff prior to data analysis.

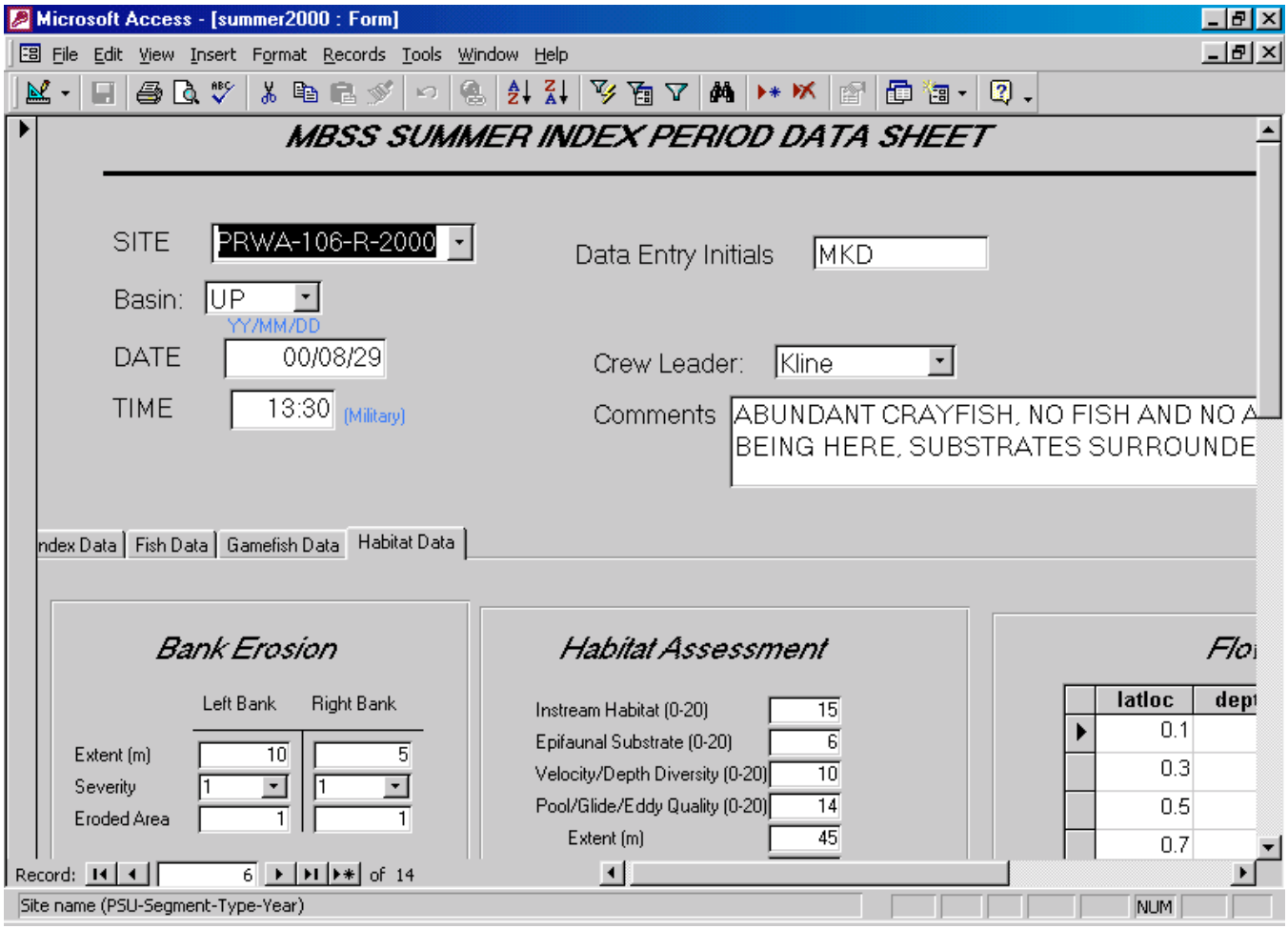

Figure 7-1. Example of MBSS data entry program in Microsoft Access

8 DATA ACQUISITION AUDITS

Even though a sophisticated survey design and rigorous sampling methods have been developed for the MBSS, the quality of the data still depends to a large degree on how well the data acquisition is accomplished. To foster high quality implementation and obtain more information on how variation in method use affects results, field audits were conducted.

8.1 FACILITIES AND EQUIPMENT

Preventive maintenance and calibration are performed on all sampling equipment used as part of the MBSS program. According to the MBSS Sampling Manual (Kazyak 2000, 2001), maintenance and calibration procedures are implemented as per manufacturers instructions. For each crew, the turbidity meter and hydrolab are calibrated daily, and the flowmeter and scale calibrated at least once a week. Calibration is also performed any time equipment problems are suspected. Preventative maintenance is performed at intervals that do not exceed the frequency recommended by the manufacturer. All equipment malfunctions should be fully corrected prior to reuse. For each piece of equipment used as part of the MBSS, a bound logbook for calibration and maintenance should be maintained. Entries in the log are made for all calibration and maintenance activities. Documentation includes detailed descriptions of all calibrations, adjustments, and replacement of parts, and each entry is signed and dated. To ensure that MBSS equipment is operated within QA/QC requirements, the QC Officer conducts several site equipment audits per year.

During MBSS 2000 sampling, according to each crew leader, logbooks were maintained that documented all calibration and maintenance activities. However, one crew was unable to locate their 2000 logbook to be reviewed for this report. The two other crews provided copies of their logbooks documenting that both the turbidity meter and hydrolab were calibrated daily, and that they zeroed the flowmeter and calibrated the scale at least once a week.

8.2 SAMPLING AUDITS

All of the standard operating procedures outlined in the MBSS sampling manual (Kazyak 2001) are intended to be strictly followed. To ensure that all procedures were properly implemented, the QC Officer conducted periodic crew audits in the field. Each audit included several or all of the following:

- a determination of correctness in locating the sampling segment using GPS equipment;
- assessment of acceptability for sampling;
- evaluation of the preparation and planning prior to field sampling;
- adherence to sampling protocols;
- field technique evaluations;
- verification of taxonomic identifications;
- checks for completeness of data sheets and field notebooks;
- equipment calibration and maintenance log review;
- a health and safety critique of crew activities; and
- data transcription.

Notes on all audits are maintained by the QC Officer and corrective actions are discussed with the Crew Leader as needed.

9 DATA QUALITY ASSESSMENT

This section describes the results of the QA/QC activities (e.g., audits described above and evaluation of the quality of the data obtained in the MBSS 2000 sampling). Separate subsections address water quality, benthic, fish, herpetofauna, aquatic vegetation, and physical habitat data. Where appropriate, both field and laboratory analysis aspects are discussed.

9.1 WATER QUALITY SAMPLING

For MBSS 2000, a review of laboratory and field records and interviews with field crew leaders confirmed that water quality samples were collected according to protocols, samples and custody sheets were properly labeled, and proper sample preservation methods were followed.

9.1.1 Field Collections

Following the standard methods in the MBSS Sampling Manual (Kazyak 2001), water quality variables were measured in situ or were collected in the field and sent to University of Maryland's Appalachian Laboratory in Frostburg for analysis. Grab samples were collected in 0.5 and 1-liter bottles for analysis of all analytes except pH. Water samples for pH were collected with 60 ml syringes, which allowed purging of air bubbles to minimize changes in carbon dioxide content.

Because of practical and cost constraints, MBSS 2000 water quality samples were stored on wet ice and generally shipped to the University of Maryland's Appalachian Laboratory in Frostburg within 48 hours. This resulted in an exceedance of the 24 hour filtering time limit for some analytes and samples. Lab experience has shown that exceeding filtering time limits for surface waters has a negligible effect on results (Ray Morgan, Appalachian Laboratory, pers. comm.).

During the spring index period, water samples were collected in the field and analyzed in the laboratory for pH, specific conductance, acid neutralizing capacity (ANC), chloride, nitrate-nitrogen, sulfate, particulate phosphorus (PP), total dissolved phosphorus (TDP), ortho-phosphate, nitrite-nitrogen, ammonia, total dissolved nitrogen (TDN), particulate nitrogen (PN), and dissolved organic carbon (DOC). Variables measured in the field during the summer index period included temperature, dissolved oxygen, pH, and conductivity.

Two types of QC samples for water chemistry are obtained during each sampling year of the MBSS. One QC sample per crew is to be a blank, while at 5% of the sites, duplicate water samples should be obtained and sent to the laboratory for analysis with the other samples from that site. During MBSS 2000, one crew did not collect the blank water quality sample. According to protocol, duplicate water quality samples were obtained at 5% (11) of the sites.

9.1.2 Laboratory Analysis

The complete report of *Quality Assurance/Quality Control Results From Spring 2000 Water Quality Chemistry Analysis for the Maryland Biological Stream Survey*, prepared by Appalachian Laboratory analysts, is presented in Appendix B. This section presents excerpts from their report.

To ensure attainment of the quality assurance objectives, standard operating procedures were implemented that include requirements for the correct performance of analytical or laboratory procedures. The quality of all data generated and processed during the spring 2000 MBSS was monitored for both precision and accuracy. The internal QA/QC protocols for chemical analysis followed guidelines from the *Handbook of Methods for Acid Deposition Studies: Laboratory Analyses for Surface Water Chemistry* (U.S. EPA 1987).

9.1.2.1 Precision

The precision of the water quality results was determined by measuring the agreement among individual measurements of the same property, under similar conditions. Precision was assessed through the analysis of laboratory duplicates or splits. The degree of agreement between replicates can be expressed as the percent relative standard deviation (RSD):

$$\text{Percent RSD} = \frac{SD}{\bar{x}} \times 100$$

Table 9-1 presents the results of the laboratory duplicate analyses and indicates that each analyte was well within its respective acceptable precision limits.

Table 9-1. Summary of precision analysis for MBSS 2000 water quality laboratory duplicates. Values are given as percent relative standard deviation (% RSD) unless otherwise noted.

Analyte	Average Precision	Acceptable Precision	N	Std. Dev.
Closed pH	0.01	0.10	54	0.04
ANC (μeq/l)	1.01	10	39	2.98
Conductance	0.68	3	42	0.87
Chloride	0.62	5	33	0.77
Nitrate-Nitrogen	0.86	5	31	0.93
Sulfate	0.68	5	33	0.72
Nitrite-Nitrogen (mg/l)	0.0004	0.05	21	0.0006
Ortho-phosphate (mg/l)	0.001	0.05	21	0.002
Ammonia (mg/l)	0.003	0.05	21	0.010
TDN	1.74	5	25	1.57
TDP	2.95	5	33	2.60
DOC	3.30	10	41	3.08
PP	1.93	5	23	2.17
PN	3.76	5	32	3.33

9.1.2.2 Accuracy

Accuracy is defined as a measure of the closeness of an individual measurement to the true or expected value. Analyzing a reference material or quality control check solution (QCCS) of known concentration is a method of determining accuracy. QCCSs were independently made and analyzed after calibration, at specified intervals during sample analysis and at the conclusion of sample analysis, to ensure accurate measurement throughout analysis. Table 9-2 presents the results of the QCCS analysis. The mean value for each analyte was within the acceptable range of accuracy. Some of the minimum and maximum values for ANC, ortho-phosphate, ammonia, TDN, TDP, DOC, and PP were outside the acceptable range. If the QCCS was not within the acceptable range, the solution was remade and analyzed again. If it failed to pass the second time, the meter was re-calibrated and all samples that were measured since the last acceptable QCCS were re-analyzed.

Table 9-2. Summary of QCCS analysis.

Analyte	Theoretical Value	Acceptable Accuracy Range	Mean	N	Std. Dev.	Min.	Max.
Closed pH	5.00	± 0.05	4.98	129	0.02	4.95	5.02
ANC (μeq/l)	200.0	± 10	196.7	35	6.5	185.6	213.2
	50.0	± 10	49.2	39	2.3	43.6	52.8
Conductance (μS/cm)	14.7	± 1.5	14.8	34	0.43	13.4	15.8
	74.0	± 4	73.2	43	1.04	71.3	76.1
	147.0	± 7.4	145.0	34	2.23	140.1	149.1
Chloride (mg/l)	2.0	± 0.2	1.874	49	0.05	1.799	2.049
Nitrate-Nitrogen (mg/l)	2.0	± 0.2	1.871	49	0.07	1.825	2.071
Sulfate (mg/l)	2.0	± 0.2	1.966	48	0.04	1.885	2.082
Nitrite-Nitrogen (mg/l)	0.05	± 0.01	0.051	36	0.002	0.047	0.053
Ortho-phosphate (mg/l)	0.05	± 0.01	0.046	36	0.008	0.039	0.057
Ammonia (mg/l)	0.05	± 0.01	0.054	36	0.006	0.037	0.061
TDN (mg/l)	0.50	± 0.05	0.514	36	0.043	0.402	0.602
TDP (mg/l)	0.05	± 0.01	0.049	49	0.005	0.039	0.062
DOC (mg/l)	10.0	± 0.5	9.88	49	0.21	9.45	10.28
	2.0	± 0.2	2.10	48	0.12	1.86	2.42
PP (mg/l)	0.10	± 0.01	0.093	45	0.005	0.084	0.102
PN (%)	10.36	± 10	10.13	43	0.16	9.09	10.51

9.1.2.3 Laboratory Blanks

Deionized water blanks served as a check of laboratory-induced contamination. Laboratory blanks were analyzed at predetermined intervals as outlined in the standard operating procedures for each analyte. Table 9-3 presents the results of the laboratory blank analyses and indicates that the mean concentration for each analyte was within the acceptable range. A few of the analytes, pH, chloride, ortho-phosphate, and ammonia had maximum concentrations that exceeded their respective acceptable limits.

Deionized water blanks were taken at two sites in order to serve as field blanks. Results are summarized in Table 9-4. Results fall into acceptable ranges for field blank analyses.

9.1.2.4 Sample Spikes

Sample spikes were used with most of the analytical techniques to determine whether the sample matrix affected analytical accuracy. A known concentration of analyte was added to about 15% of the samples. Both the spiked and unspiked samples were then analyzed. Percent recovery was calculated using the following equation:

$$\% \text{ Spike recovery} = \frac{\text{spiked sample - routine sample}}{\text{spike amount (mg/L)}} \times 100\%$$

Percent recovery calculated for sample spikes should be within 15% of 100%. Table 9-5 presents the percent recovery results and indicates that the mean concentration was well within the 15% recovery rate. Ammonia and PP had maximum concentrations that were slightly above the 15% recovery rate, and chloride had a minimum concentration just below the 15% recovery rate.

Table 9-3. Summary of laboratory blank analyses.

Analyte	Mean	Acceptable Range	N	Std. Dev.	Minimum	Maximum
Closed pH	5.52	5.40 - 6.00	47	0.19	5.29	6.15
ANC (μeq/l)	1.2	<10	33	2.7	-5.0	8.6
Conductance (μS/cm)	0.6	<1	18	0.2	0.3	0.9
Chloride (mg/l)	0.003	< 0.01	20	0.01	0	0.06
Nitrate-Nitrogen (mg/l)	BDL	< 0.01	20	BDL	BDL	BDL
Sulfate (mg/l)	BDL	< 0.01	20	BDL	BDL	BDL
Nitrite-Nitrogen (mg/l)	BDL	< 0.005	21	<0.001	-0.0002	0.0001
Ortho-phosphate (mg/l)	0.0019	< 0.005	21	0.002	-0.0013	0.0071
Ammonia (mg/l)	-0.0009	< 0.010	21	0.010	-0.0192	0.0192
TDN (mg/l)	0.0178	< 0.5	20	0.062	-0.080	0.232
TDP (mg/l)	0.0028	< 0.005	13	0.001	0.0007	0.0043
DOC (mg/l)	0.080	< 0.2	9	0.038	0.020	0.124
PP (mg/l)	0.0014	< 0.005	11	<0.001	0.0009	0.0016

BDL = Below Detection Limit

Table 9-4. Summary of field blank analyses

Analyte	Field Blank Value 1	Field Blank Value 2	Analyte	Field Blank Value 1	Field Blank Value 2
Closed pH	5.92	6.29	Ortho-Phosphate	0.0025	0.0028
ANC	8.9	-2.5	Ammonia	0.002	0.0072
Conductance	1.4	1.4	TDN	0.036	0.0536
Chloride	0.000	0.019	TDP	0.003	0.0029
Nitrate-Nitrogen	0.000	0.000	DOC	0.481	0.271
Sulfate	0.000	0.000	PP	0.000	0.000
Nitrite-Nitrogen	0.0068	0.0067			

Table 9-5. Summary of percent recovery results from sample spike analysis.					
Analyte	**Mean**	**N**	**Std. Dev.**	**Minimum**	**Maximum**
Nitrite-Nitrogen	104.0	28	4.0	92.9	112.6
Ortho-phosphate	101.9	28	7.2	85.6	114.0
Ammonia	105.5	28	4.7	94.5	115.1
Chloride	102.0	27	7.1	84.5	118.5
Nitrate-Nitrogen	99.5	28	15.9	87.0	115.3
Sulfate	95.5	30	12.6	85.3	103.8
TDN	96.9	12	6.7	85.1	109.3
TDP	98.4	20	2.8	92.5	103.4
PP	102.7	16	8.6	89.1	116.7

9.1.2.5 Collection and Analysis of Natural Audit Sample

Natural audit samples are another useful part of a comprehensive quality assurance assessment. Because they are collected from streams, they are more representative of the actual sample matrix than a manufactured calibration check solution. In January of 1997, a field natural audit sample was collected from Upper Big Run in the Savage River State Forest in order to establish an internal audit sample (FNBR001). Approximately 50 liters of sample were filtered using a 0.45 µm filter capsule and a Masterflex pump. The sample was returned to the Appalachian Laboratory where it was refrigerated for approximately 20 days and periodically checked for stability by analyzing sample ANC. Once the sample was stable, it was poured off into 500 mL aliquots. The audit samples are stored in the dark at 4 °C and are analyzed periodically for all analytes except closed pH and aluminum. Although there are no actual correct or incorrect results for any of the analytes, as when a known QCCS is measured, variations in analyte concentration can help determine or diagnose any sources of analytical error. They are especially useful as a diagnostic tool when there are any changes in the operating conditions of an instrument (i.e., column or electrode replacement). The results from the analysis of the audit sample verify the stability of the analytical results as the mean and standard deviations are similar to what Appalachian Laboratory staff typically observe (Table 9-6).

9.1.2.6 Interlaboratory Audit

The laboratory also participates in the National Water Research Institute (NWRI) Ecosystem Interlaboratory Quality Assurance Program annually as an additional quality assurance measure. Twelve natural water samples were analyzed for the following analytes: open pH, specific conductance, DOC, ANC, nitrate-nitrogen, ammonia, total phosphorus, total nitrogen, sulfate, and chloride. Results from the spring 2000 study were good with the laboratory receiving ideal ratings for six of the analytes (Table 9-7).

9.1.2.7 Field Duplicates

In the spring index period, 213 sites were sampled for water quality. Field duplicates were obtained from eleven sites (5%). Precision of the duplicate samples was determined by measuring the Relative Percent Difference (RPD).

$$RPD = (|X1-X2|*100)/((X1+X2)/2)$$

Lower RPDs indicate greater precision, therefore, nitrite (0% RPD) and chloride (0.27% RPD), which had the lowest RPDs, are considered to have the greatest precision (Table 9-8).

Twenty percent RPD was selected as a general "rule of thumb" threshold for evaluating precision within pairs of samples. Two analytes, PN and PP, had the greatest number of paired samples with RPDs greater than 20% and had median RPDs greater than 20% (Table 9-8).

Table 9-6. Natural audit sample analytical results.					
Analyte	**Mean**	**N**	**Std. Dev.**	**Minimum**	**Maximum**
ANC	35.8	22	3.22	30.2	44.7
Conductance	28.8	17	1.13	26.3	30.7
Chloride	0.785	19	0.04	0.749	0.943
Nitrate-Nitrogen	0.166	19	0.06	0.143	0.429
Sulfate	7.150	18	0.07	7.043	7.327
DOC	0.660	10	0.05	0.585	0.723

Table 9-7. Summary of results from 2000 NWRI interlaboratory audit.	
Analyte	**Rating**
Conductance	Ideal
Open pH	Ideal
DOC	Ideal
ANC	Flagged high on 1 sample
Nitrate-Nitrogen	Flagged low on 3 samples
Ammonium	Flagged low on 3 samples
Total Phosphorus	Ideal
Total Nitrogen	Ideal
Sulfate	Ideal
Chloride	Flagged low on 1 sample

Table 9-8. Summary of field duplicate RPD results			
Analyte	**Pairs of Samples with RPD > 20%**	**Percent of Pairs of Samples with RPD > 20%**	**Median RPD**
PH	0	0%	0.58
Conductance	0	0%	0.79
ANC	0	0%	0.58
Chloride	0	0%	0.27
Nitrate-Nitrogen	0	0%	0.74
Sulfate	0	0%	0.44
PP	6	55%	20.80
TDP	3	27%	11.76
Ortho-phosphate	3	27%	16.13
Nitrite-Nitrogen	0	0%	0.00
Ammonia	1	9%	3.64
TDN	2	18%	11.22
PN	8	73%	25.61
DOC	2	18%	5.03

9.2 BENTHIC SAMPLING

9.2.1 Field Collections

Following the method detailed in Kazyak (2001), MBSS 2000 benthic samples were collected in areas most likely to support the greatest benthic taxonomic diversity, preferably in riffle areas, but other habitat types were also sampled. A 600 micron mesh D-net was used to collect the sample. Each "jab" of the D-net covered one square foot of area, and a total of approximately 2.0 square meters (20 square feet) was sampled and preserved in 70% ethanol.

The index period for benthic sampling occurs between March 1 and May 1, with the end of the index period being determined by degree-day accumulation as specified in Hilsenhoff (1987). For the 2000 field season, all benthic sampling occurred during this index period, with the first samples taken on March 1, 2000 and the last samples taken on May 1, 2000. Also, during the 2000 field season, it was noted that there were no problems with the labeling and preservation of the benthic samples.

Duplicate field samples were taken at 13 sites (6% of all sites sampled) during the 2000 sampling. These duplicates were taken in the same segment as the original sample and preserved in separate bottles to be sent to the laboratory and identified. To determine the replicability of the benthic IBI score and its component metrics, the benthic IBI analysis was run on the duplicate samples taken at each of these sites.

Table 9-9 shows the results of this analysis. For the three metrics that the Coastal Plain and non-Coastal Plain IBIs have in common (Number of Taxa and Number of EPT taxa, and Percent Ephemeroptera), the R^2 of a linear regression between the original data and the field duplicates ranged between 0.56 and 0.95. The mean Coefficient of Variation (CV; the ratio of the standard deviation to the mean) for individual metrics varied from 0.15 to 0.27, while the median Relative Percent Difference (RPD; see Section 8.1) varied from 18.18% to 40.00%. From six to nine sites had an RPD greater than 20%.

Four metrics apply only to the Coastal Plain, where six duplicate sites were sampled in 2000. For these metrics (Percent Tanytarsini of Chironomidae, Beck's Biotic Index, Number of Scraper Taxa, and Percent of Clingers), the R^2 of the linear regression analysis ranged between 0.47 and 0.78. The CV varied between 0.35 and 0.74. The median RPD (excluding the sites with one value of zero for the metric in question) for these metrics varied from 0.00 to 65.63 and from two to four sites had RPD values greater than 20%.

Table 9-9. Benthic IBI component metrics and final score comparisons for the 13 duplicate field samples taken during the 2000 MBSS.

Metric	N*	R^2	Mean Original Sample	Mean Duplicate Sample	Mean CV	Median RPD	Number of Sites with RPD > 20%
Number of Taxa	13	0.62	20.31	19.46	0.15	18.18	6
Number of EPT Taxa	13	0.56	5.31	5.00	0.27	40.00	9
Percent Ephemeroptera	13	0.95	13.53	11.76	0.20	26.97	7
Percent Tanytarsini of Chironomidae	6(4)	0.47	16.86	9.96	0.74	65.63	3
Beck's Biotic Index	6(5)	0.47	4.50	3.33	0.51	40.00	4
Number of Scraper Taxa	6(5)	0.76	2.50	1.83	0.43	0.00	2
Percent of Clingers	6	0.78	10.50	8.56	0.35	24.24	3
Number of Ephemeroptera	7	0.96	18.86	17.29	0.18	1.68	3
Number of Diptera	7	0.66	9.75	10.29	0.26	28.57	5
Percent Tanytarsini	7(5)	0.98	10.93	9.00	0.49	4.57	2
Number of Intolerants	7	0.70	7.22	8.57	0.14	20.00	3
Percent Tolerant	7	0.96	24.18	23.52	0.17	15.74	3
Percent Collectors	7	0.88	44.07	49.03	0.14	23.78	3
Benthic IBI	13	0.70	3.21	2.83	0.09	15.79	6

* Values in parentheses indicate the number of sites used in the RPD analysis when sites containing one value of zero were excluded from the analysis

The remaining six metrics apply to only the sites in the non-Coastal Plain region of the state (n=7 pairs of duplicates). For these metrics (Number of Ephemeroptera Taxa, Number of Diptera Taxa, Percent Tanytarsini, Number of Intolerant Taxa, Percent Tolerant Taxa, and Percent Collectors), the R^2 of the linear regression analysis varied from 0.70 to 0.98. The CV varied from 0.14 to 0.49 and the median RPD varied from 1.86 to 28.57. From zero to five sites had an RPD greater than 20%.

At these 13 sites, the mean benthic IBI for the original data was 3.21, while the mean for the duplicate data was 2.83. The R^2 of the linear regression was 0.70 and the CV for the benthic IBI was 0.09, comparable to the results for duplicate sites sampled in the first round of the MBSS (CV of 0.08, Roth et al. 2001b). The median RPD was 15.79 and six sites had an RPD greater than 20%. These results indicate that there is generally little difference between duplicate samples taken at the same site, although it must be noted that the original sample tended to score higher than the duplicate sample.

Taxa lists for the original and duplicate samples were also examined in order to look for differences in what taxa were sampled in the same 75-m segment. These lists, with the percent contribution of each taxon to the total number of individuals found in the sample, can be found in Appendix C. In eight of the 13 sites (62%) where field duplicates were taken, the same taxon made up the greatest proportion of individuals in both the original data and in the duplicate data. Overall, there was a high degree of similarity in the taxa found in the original and in the duplicate, although there were some discrepancies that can be attributed to both differences in field collection procedures and in laboratory subsampling and identification. To isolate differences that result from laboratory subsampling (i.e., selection of a 100-organism subsample from the full sample collected), a separate set of benthic laboratory duplicates was analyzed, as described below.

9.2.2 Laboratory Sampling

MBSS benthic samples are shipped to the DNR field office and assigned an unique sample log number. Sample buckets are checked for adequate quantities of preservatives and for cracks or poorly fitted lids. Samples are stored in an area with good ventilation until processed. The preserved sample is then transferred to a gridded pan and organisms are picked from randomly selected grid cells until the cell that contains the 100th individual (if possible) is completely picked. Some samples may have fewer than 100 individuals. For the MBSS, benthic macroinvertebrates are identified to genus, or the lowest practicable taxonomic level. Questionable identifications are verified by consulting DNR benthic taxonomists, regional experts, and regional keys for certain taxonomic groups. A complete description of laboratory protocols can be found in Boward and Friedman (2000).

Using the unique log numbers, approximately every 20th sample is randomly chosen for re-subsampling and identification. Each sample is subsampled and identified as usual, except that chironomids are identified to subfamily or tribe (eliminating the need to slide mount the larvae of this family). The identified organisms are returned to the sample bucket and the bucket is re-subsampled. This second subsample is identified according to standard procedures and comparisons are made between the two duplicates.

In the 2000 MBSS, 16 samples were chosen for this QC analysis. Because taxa in the duplicate subsample were identified to higher taxonomic levels than taxa in the original sample, taxa in the original were also grouped up to these higher levels. The benthic IBI analysis was run on these new taxa lists and individual metrics were compared as in the analysis of the field duplicates above.

Table 9-10 shows the results of this analysis. For the three metrics that the Coastal Plain and non-Coastal Plain IBIs have in common (Number of Taxa and Number of EPT taxa, and Percent Ephemeroptera), the R^2 of a linear regression between the original data and the field duplicates ranged between 0.55 and 0.94. The CV varied from 0.16 to 0.31, while the median Relative Percent Difference (RPD; see Section 8.1) varied from 17.66% to 21.04%. From five to seven sites had an RPD greater than 20%.

Four metrics apply only to the eleven Coastal Plain sites that were sampled in 2000. For these metrics (Percent Tanytarsini of Chironomidae, Beck's Biotic Index, Number of Scraper Taxa, and Percent of Clingers), the R^2 of the linear regression analysis ranged between < 0.01 and 0.82. The CV varied between 0.17 and 0.55. The median RPD (excluding the sites with one value of zero for the metric in question) for these metrics varied from 0.00 to 44.28 and from four to six sites had RPD values greater than 20%.

The remaining six metrics apply to only the five sites in the non-Coastal plain region of the state. For these metrics (Number of Ephemeroptera Taxa, Number of Diptera Taxa, Percent Tanytarsini, Number of Intolerant Taxa, Percent Tolerant Taxa, and Percent Collectors), the R^2 of the linear regression analysis varied from 0.04 to 0.95. The CV varied from 0.11 to 0.72 and the median RPD varied from 6.32 to 43.28. From one to five sites had an RPD greater than 20%.

Although a true benthic IBI can not technically be calculated for these duplicate data because of the lumping of the chironomid taxa, a hypothetical IBI was calculated and the results of the original sample were compared with the results from the duplicate sample. At the 16 sites where laboratory duplicates were taken, the mean benthic IBI for the original data was 3.02, while the mean for the duplicate data was 2.95. The R^2 of the linear regression was 0.85 and the CV was 0.06. The median RPD was 5.83 and only two sites had an RPD greater than 20%. These results indicate that although there is variation between duplicates in the individual metrics that make up the benthic IBI, this variation does not dramatically affect the final IBI score. In fact, at seven of the 16 sites (44%), there was no difference in IBI score even though the values of the individual metrics varied.

Taxa lists for the original and duplicate subsamples were also examined in order to look for differences in what taxa were randomly picked from the sampling grid. These lists, with the percent contribution of each taxon to the total number of individuals found in the subsample, can be found in Appendix D. In 10 of the 16 sites (63%) where laboratory duplicates were taken, the same taxon made up the greatest proportion of individuals in both the original data and in the duplicate data. Overall, there was a high degree of similarity in the taxa found in the original and in the duplicate, although the random nature of the subsampling process leads to inherent differences in the taxa being included in these lists.

9.3 FISH SAMPLING

According to MBSS protocols, fish are sampled during the summer index period from June 1 and September 30 (Kazyak 2001). During MBSS 2000 sampling, one site in the Lower Wicomico watershed was sampled on October 3, 2000, just slightly beyond the summer index period, because frequent rain events causing high levels of turbidity earlier in summer had prevented electrofishing in larger streams.

Fish are sampled using double-pass electrofishing within 75-meter stream segments. Block nets are placed at each end of the segment and direct current backpack electrofishing units are used to sample the entire segment. Any individual fish that cannot be identified should be retained for laboratory confirmation. In addition, 10 voucher specimens of each species will be retained for each major (Maryland 6-digit) drainage basin during the 2000-2004 MBSS.

During MBSS 2000, 82,488 individuals representing 70 species and 3 genera (not initially identifiable to species) were sampled in the field. Following MBSS protocols

Table 9-10. Benthic IBI component metrics and final score comparisons for the 16 duplicate laboratory samples taken during the 2000 MBSS.

Metric	N*	R^2	Mean Original Sample	Mean Duplicate Sample	Mean CV	Median RPD	Number of Sites with RPD > 20%
Number of Taxa	16	0.55	17.94	16.94	0.16	17.66	7
Number of EPT Taxa	16	0.88	5.31	4.69	0.31	21.04	5
Percent Ephemeroptera	16	0.94	13.09	11.22	0.29	14.78	5
Percent Tanytarsini of Chironomids	11(9)	< 0.01	10.09	16.27	0.55	23.26	4
Beck's Biotic Index	11(10)	0.68	5.09	4.64	0.32	23.61	6
Number of Scraper Taxa	11	0.62	3.36	2.73	0.17	0.00	4
Percent of Clingers	11	0.82	41.78	37.86	0.38	44.28	6
Number of Ephemeroptera	5(3)	0.91	6.40	5.80	0.72	34.48	2
Number of Diptera	5	0.04	6.20	6.60	0.13	15.38	1
Percent Tanytarsini	5(4)	0.95	25.22	23.03	0.45	21.51	2
Number of Intolerants	5	0.83	9.50	9.50	0.15	22.22	5
Percent Tolerant	5	0.88	22.50	17.90	0.25	43.28	4
Percent Collectors	5	0.82	54.22	60.06	0.11	6.23	2
Benthic IBI	16	0.85	3.02	2.95	0.06	5.83	2

* Values in parentheses indicate the number of sites used in the RPD analysis when sites containing one value of zero were excluded from the analysis

(Kazyak 2001), most fish were identified in the field and released. When field crew leaders were uncertain of identification, a "best guess" name was recorded and the individual was retained for laboratory identification. Laboratory identification can serve to distinguish between two closely related species, particularly when features not easily observed in the field provide the needed evidence for positive identification. In other cases (e.g., *Lepomis* hybrids), the expertise of an ichthyologist specialist aids in hybrid confirmation.

All voucher specimens and fish retained for positive identification were examined and verified by Dr. Rich Raesly, an ichthyologist at Frostburg State University, Frostburg, Maryland. All MBSS collections are archived in the fish museum at Frostburg State University. Seventy-three taxa comprising 70 species and 3 genera (2,756 individuals) were collected and retained as voucher specimens or for positive identification during the summer index period of MBSS 2000. Ninety percent (2,486 individuals) of the specimens had been correctly identified in the field. Five species at 6 sites were initially identified incorrectly in the field but retained. *Notropis rubellus* (98 fish at 2 sites), *Cyprinella spilopter* (4 fish at 1 site) and *Luxilus cornutus* (1 fish at 1 site) were all incorrectly identified as *Notropis amoenus*. *Petromyzon marinus* (1 individual at 1 site) was incorrectly identified as *Lampetra appendix*, and *Lepomis auritus* x *L. megalotis* hybrid (1 fish at 1 site) was incorrectly identified as *Lepomis auritus*. Five species at 8 sites were identified only to genus. *Notropis rubellus* (92 fish at 2 sites), *Notropis amoenus* (2 fish at 1 site), and *Cyprinella spilopter* (1 fish at 1 site) were identified as *Notropis* sp. *Enneacanthus obesus* (72 fish at 3 sites) and *Enneacanthus gloriosus* (3 fish at 1 site) were identified as *Enneacanthus* sp. After positive identification was made by Dr. Raesley, the appropriate modifications were made to the data sets prior to analysis and reporting. In the Middle Potomac River basin at site UMON-229-R-2000, an individual fish was identified as an unknown cyprinid, but was not retained for positive identification.

Over time the MBSS is establishing a voucher collection of fish as a long-term archive. During each round of sampling, the goal is to archive 10 individuals of each species per 6-digit basin. During MBSS 2000, 10 individuals per species were not sampled in every basin and, therefore, could not be retained. For each 6-digit basin, there were a number of species where the number of individuals sampled exceeded 10, but where the number of voucher specimens retained was less than 10, or when the number of individuals sampled was less than 10, fewer individuals than the number sampled were retained. Appendix E presents a table of fish species by the number that were sampled and the number that were retained in each 6-digit basin. None of the 17 species in the Youghiogheny River basin were retained for voucher specimens. It is important to note there are four more years in the second round of the MBSS to obtain at least 10 individuals per species in each basin.

9.4 HERPETOFAUNA SAMPLING

At each segment sampled during the MBSS 2000 summer index period, amphibians and reptiles encountered during the course of electrofishing and other activities were captured, identified, and recorded. Individuals were identified to species when possible. Voucher specimens of adults were retained for each species new to each 6-digit drainage basin; larval salamanders and tadpoles were not retained. Amphibians and reptiles encountered and positively identified during spring index period sampling were recorded in the notes section of the data sheets.

9.5 AQUATIC VEGETATION SAMPLING

During the summer index period, aquatic vegetation was sampled qualitatively by examining each 75-meter stream segment for the presence of aquatic plants. The presence and relative abundance of submerged, emergent, and floating aquatic vegetation were recorded. Because there is no practical easy way to preserve aquatic vegetation, taxonomic identification was made optional for the 2000-2004 MBSS. No quality assurance was performed for aquatic vegetation sampling.

9.6 PHYSICAL HABITAT SAMPLING

9.6.1 Spring Index Period

Physical habitat assessments are conducted during both spring and summer index periods. Following the MBSS Sampling Manual protocols (Kazyak 2001) for the spring, riparian zone vegetation type is noted and width on each bank is estimated to the nearest meter (up to 50 meters from the stream). The severity and type of buffer breaks, local land use type, and extent and type of stream channelization are recorded. Altitude and stream gradient are measured. Crews also record distance from road and assign an aesthetic rating (based on visible signs of human refuse at a site) to characterize human presence. The QC Officer makes independent habitat assessments of approximately 10% of the total number of sites sampled during the spring index period.

During the 2000 spring index period, the QC Officer conducted habitat assessments at 20 sites (approximately 9.5% of the 211 sites sampled). Most of the habitat data obtained during the spring index period is qualitative. Overall, there is very good correspondence between the QC Officer's and field crews' qualitative data (Table 9-11). For example, in identifying adjacent land cover (e.g., cropland, forest, etc.), only two variables (type of riparian vegetation on both left and right banks) were in disagreement at more than 20% of the sites. In most cases, the differences were due to the QC Officer identifying more types of vegetation on the bank than the sampling crews, rather than a discrepancy between vegetation types identified. For example, at LIBE-117-R-2000 in the Patapsco River basin, both the sampling crew and QC Officer identified regenerating deciduous/shrubs, mature deciduous, and old deciduous vegetation along the right bank. However, the QC Officer also recorded grasses/forbes along the right bank.

There were 18 quantitative variables measured or estimated during the spring index period: distance from road; aesthetic rating; altitude; width of riparian vegetation on left and right bank, extent of concrete, gabions, riprap, berm, pipe, and dredge spoil channelization on left and right bank, and bottom of channel. None of the sites audited had any concrete, gabion, or riprap channelization on either bank or bottom of channel, berm on the bottom of channel, or dredge spoils on the left bank or bottom of channel. As these variables were not detected at any of the sites, they were not included in the table below. Table 9-12 shows that

Table 9-11. Comparison of spring habitat qualitative results between sampling crews and QC Officer.

Variable	# Samples Different	Total # of Samples	% of Samples Different
Adjacent cover - left bank	4	20	20%
Adjacent cover - right bank	2	20	10%
Buffer breaks - left bank	1	20	5%
Buffer breaks - right bank	1	20	5%
Vegetation type - left bank	7	20	35%
Vegetation type - right bank	9	20	45%
Old field presence (Y/N)	4	20	20%
Deciduous forest presence (Y/N)	0	20	0%
Coniferous forest presence (Y/N)	4	20	20%
Wetland presence (Y/N)	4	20	20%
Surface mine presence (Y/N)	0	20	0%
Landfill presence (Y/N)	0	20	0%
Residential land presence (Y/N)	3	20	15%
Commercial/Industrial land presence (Y/N)	1	20	5%
Cropland presence (Y/N)	1	20	5%
Pasture presence (Y/N)	0	20	0%
Orchard/Vineyard/Nursery presence (Y/N)	1	20	5%
Evidence of Dredging (Y/N)	2	20	10%

Table 9-12. Comparison of spring habitat quantitative results between sampling crews and QC Officer.

Variable	N*	Mean Original Sample	Mean Duplicate Sample	Mean CV	Median RPD	Number of Sites with RPD > 20%
Distance from Road (m)	17	289.20	350.59	0.16	11.57	6
Aesthetic Rating (1-20)	20	16.90	16.70	0.09	5.89	4
Altitude (m)	4	164.25	159.75	0.01	0.59	0
Width of riparian vegetation - left bank (m)	20	39.90	40.65	0.02	0	1
Width of riparian vegetation - right bank (m)	20	40.35	40.25	0.003	0	0
Extent of left bank earthen berm (m)	5(4)	15.79	17.63	0.10	0	1
Extent of right bank earthen berm (m)	5(4)	15.79	17.63	0.10	0	1
Extent of pipe on left bank (m)	2	1.32	1.42	0.01	0	0
Extent of pipe on bottom (m)	2	1.32	1.42	0.01	0	0
Extent of pipe on right bank (m)	2	1.32	1.42	0.01	0	0
Extent of dredge spoil offchannel on right bank(m)	2(1)	1.68	5.53	0.68	0	0

* Values in parentheses indicate the number of sites used in the RPD analysis when sites containing one value of zero were excluded.

none of the detected variables had an RPD greater than 20%, indicating a good correspondence between the sampling crew and QC Officer's data, even though some of these values (e.g, distance from road) are estimated visually rather than actually measured. However, for some of the estimated variables describing the extent of earthen berm, pipe, and dredge spoil, the QC Officer and field crews had two results (extent of left and right bank earthen berm) that disagreed by 40 meters (QC Officer 35 meters versus field crew 75 meters), and 3 results (extent of left and right bank earthen berm, and extent of dredge spoil offchannel on right bank) that disagreed by 75 meters (QC Officer 75 meters and field crew 0 meters). In each of these cases, channelization was of a historical nature and difficult to evaluate.

9.6.2 Summer Index Period

Following the MBSS Sampling Manual protocols (Kazyak 2001) for the summer index period, several habitat characteristics (instream habitat, epifaunal substrate, velocity/ depth diversity, pool/glide/eddy quality, and riffle/run quality) are assessed qualitatively on a 0-20 scale, based on visual observations within each segment and following standardized narrative descriptions. The percentage of embeddedness of the stream channel and the percentage of shading of the stream site are estimated. Also recorded are the extent and severity of bank erosion and bar formation, number of woody debris and rootwads within the stream channel, and the presence of various stream features such as substrate types, various morphological characteristics, and beaver ponds. Maximum depth within the segment is also measured. Wetted width, thalweg depth, and thalweg velocity are recorded at four transects.

The QC Officer made independent habitat assessments of 15 sites during the 2000 summer index period (7.5% of the 199 sites sampled). For the qualitative data, 13 variables were in disagreement at more than 20% of the sites (Table 9-13). These variables were severity of bank erosion (right bank), extent of bar formation (minimum, moderate, and extensive), substrate of bar formation (sand and silt/clay), relative abundance of multiflora rose, and presence of riffles, runs/glides, shallow pools, sand, silt/clay, and overhead cover.

To assess whether differences could be attributed to the difficulty in standardizing how individuals differentiate between minimum, moderate, and severe categories, or present and extensive categories, we reanalyzed several variables by grouping the moderate and severe categories, and present and extensive categories. Grouping of these category levels tended to improve the agreement between the field crew and QC Officer. Only 4 (minimum bar formation, sand and silt/clay bar formation, and presence of overhead cover) of the 13 variables that were originally in disagreement at greater than 20% of the sites remained above this threshold after grouping of the category levels. For example, severity of erosion on the right bank variable disagreed between the sampling crew and QC Officer at 33% of the sites; however after regrouping, only 3 (20%) of the sites were in disagreement (Tables 9-13 and 9-14).

As seen in Tables 9-14 through 9-17 apparent disagreements between the QC Officer and sampling crew most often represent a difference of only one category.

As seen in Table 9-13, minimum, moderate and extensive bar formation variables each had disagreements at more than 20% of the sites. However, after regrouping, both moderate and severe bar formation disagreements change to 3 sites (20%) (Table 9-15).

For the results of the extent of exotic plants, only multiflora rose had disagreement of results at more than 20% of the sites (33%) (Table 9-16). However, if the present and extensive categories are combined, there is only 1 site (7%) for multiflora rose that has a discrepancy between absent and present/extensive. Japanese Honeysuckle had disagreement of results at 20% of the sites, and 2 sites (14%) still have a discrepancy after combining the present and extensive categories.

Six of the fifteen variables for stream character (riffle, run/glide, shallow pool, sand, silt/clay, and overhead cover) had discrepancies between results at greater than 20% of the sites. However, if the present and extensive categories are combined, there are only 2 sites (13%) for riffle and 4 (27%) for overhead cover that have discrepancies remaining between absent and present/extensive (Table 9-17).

There were 19 quantitative variables measured or estimated during the summer index period (Table 9-18). Eleven of these variables (extent of bank erosion on left and right bank, eroded area on left and right bank, number of instream woody debris, number of dewatered woody debris, number of instream rootwads, number of dewatered rootwads, quality and extent of riffle/run, and embeddedness) had an RPD greater than 20% indicating that there was not very good correspondence between the sampling crew and QC Officer's data for these variables. As indicated by their high median RPD values, extent of bank erosion (left bank 40.00 and right bank 37.53) and eroded area of bank (left bank 46.32 and right bank 58.82)

may be difficult to accurately estimate. The discrepancy between sampling crew and QC Officer counts for woody debris were primarily due to large differences at one site. (Note that the variables scored with 1 to 20 ratings (based on standard descriptions) were among the best performers.

9.6.3 Temperature Loggers

During the 2000 MBSS, automated temperature loggers were placed at 189 of the randomly selected sites. Prior to field sampling, all temperature loggers were calibrated by placing them into a bucket of water of a known temperature; no significant deviations were recorded. Loggers were deployed during spring sampling. Field crews made the best attempt possible to position the loggers in areas where they would stay under water and out of direct sunlight. The temperature loggers were set to begin recording on June 1 and recorded the water temperature every 20 minutes until they were removed (generally in mid- to late August).

Of the 189 sites where temperature loggers were initially placed, the loggers were lost at 20 (11%) of those sites. Because the loggers were placed in the spring, during the period of high water, many of the streams dried up at some point during the summer, leaving the temperature logger recording air temperature. Data were screened for outliers (temperatures greater than 30 °C) and Field Crew Leaders were consulted for information concerning the condition of the streams where these high temperatures were being recorded. Because of the uncertainty at these stations about whether a high temperature was due to an actual increase in water temperature or because the stream had dried up, the data for the temperature loggers were not used in subsequent analyses at the sites that were dry when checked by crews during summer sampling or when the temperature logger was retrieved in August. This uncertainty occurred at 19 of the 169 (12%) of the sites where temperature data could be retrieved. Uncertain data were excluded from subsequent data analyses.

Table 9-13. Comparison of summer habitat qualitative results between sampling crews and QC Officer.

	Original Data			Grouped Data*		
Variable	**# Samples Different**	**Total # of Samples**	**% of Samples Different**	**# Samples Different**	**Total # of Samples**	**% of Samples Different**
Severity of bank erosion - left (1,2,3)	3	15	20%	1	15	7%
Severity of bank erosion - right (1,2,3)	5	15	33%	3	15	20%
No bar formation	2	15	13%	2	15	13%
Minimum bar formation	8	15	53%	8	15	53%
Moderate bar formation	4	15	27%	3	15	20%
Extensive bar formation	4	15	27%	3	15	20%
Cobbles present	2	15	13%	NA	NA	NA
Gravel present	1	15	7%	NA	NA	NA
Sand present	4	15	27%	NA	NA	NA
Silt/Clay present	5	15	33%	NA	NA	NA
Relative abundance of multiflora rose (A,P,E)	5	15	33%	1	15	7%
Relative abundance of Mile-a-Minute (A,P,E)	1	14	7%	0	14	0%
Relative abundance of Japanese Honeysuckle (A,P,E)	3	15	20%	2	15	13%
Relative abundance of Reed Canary Grass (A,P,E)	0	15	0%	0	15	0%
Relative abundance of Thistle (A,P,E)	1	15	7%	1	15	7%
Relative abundance of other exotic (A,P,E)	0	15	0%	0	15	0%
Type of other exotic	0	15	0%	NA	NA	NA
Stream braided (A,P,E)	3	15	20%	3	15	20%
Riffle (A,P,E)	6	15	40%	2	15	13%
Run/Glide (A,P,E)	8	15	53%	0	15	0%
Deep Pool (>=.5m) (A,P,E)	2	14	14%	2	14	14%
Shallow Pool (<.5m) (A,P,E)	10	15	67%	0	15	0%
Boulder >2m (A,P,E)	1	15	7%	1	15	7%
Boulder <2m (A,P,E)	1	15	7%	0	15	0%
Cobble (A,P,E)	1	15	7%	0	15	0%
Bedrock (A,P,E)	3	15	20%	3	15	20%
Gravel (A,P,E)	3	15	20%	0	15	0%
Sand (A,P,E)	5	15	33%	0	15	0%
Silt/Clay (A,P,E)	5	15	33%	0	15	0%
Undercut Bank (A,P,E)	3	15	20%	1	15	7%
Overhead Cover (A,P,E)	7	15	47%	4	15	27%
Beaver Pond (A,P,E)	0	15	0%	0	15	0%

* Moderate and severe, and present and extensive categories were grouped together.
1= Minimum, 2 = Moderate 3 = Severe
A = Absent, P = Present, E = Extensive

Table 9-14. Comparison of severity of erosion on left and right banks between the sampling crews and QC Officer

Left Bank

Sampling Crew \ QC Officer	None	Min	Mod	Sev
None	2			
Min		2		1
Mod			6	2
Sev				2

Right Bank

Sampling Crew \ QC Officer	None	Min	Mod	Sev
None	2	1		
Min			2	
Mod			4	2
Sev				4

Min = minimum, Mod = moderate, Sev = Severe

Table 9-15. Comparison of extent of bar formation between the sampling crews and QC Officer

Sampling Crew \ QC Officer	None	Min	Mod	Sev
None	3	1		
Min	1	1	1	1
Mod		2		1
Sev		2		2

Min = minimum, Mod = moderate, Sev = Severe

Table 9-16. Comparison of extent of exotic plants between the sampling crews and QC Officer

Multiflora Rose

Sampling Crew \ QC Officer	A	P	E
A	5	1	
P		2	4
E			3

Mile-a-Minute

Sampling Crew \ QC Officer	A	P	E
A	7		
P		5	1
E			1

Missing 1 QC result

Japanese Honeysuckle

Sampling Crew \ QC Officer	A	P	E
A	4	1	1
P	1	6	
E			2

Reed Canary Grass

Sampling Crew \ QC Officer	A	P	E
A	15		
P			
E			

A=absent, P=present, E=extensive

Table 9-17. Comparison of stream character between the sampling crews and QC Officer

Braided

Sampling Crew \ QC Officer	A	P	E
A	10	3	
P		1	
E			1

Riffle

Sampling Crew \ QC Officer	A	P	E
A	1		
P	1	6	3
E	1	1	2

Run/Glide

Sampling Crew \ QC Officer	A	P	E
A			
P		1	7
E		1	6

Deep Pool (>=0.5m)

Sampling Crew \ QC Officer	A	P	E
A	4		
P	2	8	
E			

Missing 1 QC result

Shallow Pool (<0.5m)

Sampling Crew \ QC Officer	A	P	E
A			
P		2	7
E		3	3

Boulder (>2m)

Sampling Crew \ QC Officer	A	P	E
A	12		
P	1	2	
E			

Boulder (<2m)

Sampling Crew \ QC Officer	A	P	E
A	4		
P		9	1
E			1

Cobble

Sampling Crew \ QC Officer	A	P	E
A	3		
P		3	1
E			8

Bedrock

Sampling Crew \ QC Officer	A	P	E
A	10	3	
P		2	
E			

Gravel

Sampling Crew \ QC Officer	A	P	E
A	2		
P		3	2
E		1	7

Sand

Sampling Crew \ QC Officer	A	P	E
A			
P		5	4
E		1	5

Silt/clay

Sampling Crew \ QC Officer	A	P	E
A			
P		6	5
E			4

Undercut Bank

Sampling Crew \ QC Officer	A	P	E
A	2	1	
P		9	2
E			1

Overhead Cover

Sampling Crew \ QC Officer	A	P	E
A		2	
P	2	5	1
E		2	3

A=absent, P=present, E=extensive

Table 9-18. Comparison of summer habitat quantitative results between sampling crews and QC Officer.

Variable	N	Mean Original Sample	Mean Duplicate Sample	Mean CV	Median RPD	Number of Sites with RPD > 20%
Extent of bank erosion - left bank (m)	15	24.87	23.20	0.22	40.00	8
Extent of bank erosion - right bank (m)	15	28.80	27.60	0.26	37.53	10
Eroded area of left bank (m2 x 10)	15	2.80	2.33	0.41	46.32	9
Eroded area of right bank (m2 x 10)	15	3.73	3.00	0.31	58.82	9
No. of instream woody debris	15	9.67	4.13	0.38	50.00	10
No. of dewatered woody debris	15	23.47	4.13	0.55	59.65	12
No. of instream rootwads	15	10.80	5.60	0.46	66.67	8
No. of dewatered rootwads	15	7.80	9.27	0.29	43.17	10
Instream habitat rating (1-20)	15	14.13	13.60	0.07	11.76	1
Epifaunal substrate rating (1-20)	15	12.20	12.13	0.10	8.70	1
Velocity/depth diversity rating (1-20)	15	12.13	11.13	0.14	10.53	3
Pool/glide/eddy quality rating (1-20)	15	12.73	12.20	0.08	8.70	3
Extent of Pool/glide/eddy (m)	15	54.60	50.87	0.14	14.14	6
Riffle/run quality rating (1-20)	15	12.07	12.33	0.31	20.69	8
Extent of riffle/run (m)	15	35.93	48.40	0.45	37.84	10
Embeddedness (%)	15	37.47	43.33	0.30	47.62	12
Shading (%)	15	69.47	66.87	0.17	9.79	6

10 REPORTING

Versar is responsible for writing and producing the MBSS annual report that analyzes and summarizes the data from each sampling year. Versar has developed detailed QA/QC procedures for document production to ensure that technical reports are of the highest quality and meet DNR's specific needs. Versar's report production procedure involves internal reviews by senior scientists who were not major authors, copy-editing, routine electronic spelling checks, and review of copies for production flaws before delivery to the client. For MBSS reports, the MBSS QC Officer also reviews all text and graphics prior to completion of the draft report. In addition to internal technical review, all major deliverables (draft and final versions) are copy-edited by a trained technical editor to ensure completeness, accuracy, consistency, and conformity to accepted style conventions (e.g., Government Printing Office Style Manual, Council of Biology Editors Style Manual, Chicago Manual of Style) and the clients' specifications for format and usage. The QA/QC procedure helps ensure that all comments on drafts are addressed before delivery of the final. MBSS reports are also peer reviewed by DNR and three independent reviewers prior to final publication.

11 QA/QC RECOMMENDATIONS

Overall, the results of our analysis of the QA data for the 2000 MBSS indicate that the rigorous training and adherence to the MBSS Sampling Manual (Kazyak 2000) is providing excellent data that can be used with confidence. We recommend the continuation of the rigorous training and adherence to all established QA/QC procedures in future years.

Additional specific recommendations to consider for incorporation into future MBSS protocols are as follows:

- Continue this QA Report as a means for external evaluation of MBSS data quality;
- Standardize the recording of observations made during field audits. Consider using a standardized QC checklist to facilitate quantitative reporting;
- Standardize the documentation of the numerous QC checks performed throughout data management and analysis. Consider using a standardized QC checklist to provide a detailed summary of specific QC actions;
- Develop MBSS-specific SOP's for all phases of the MBSS, including the analytical laboratory;
- Improve recordkeeping to identify sites where crew was in doubt about actual location;
- Require that all equipment calibration logs be turned into QC Officer at the end of each sampling season and archived;
- Develop a genus-level taxonomic key for benthos in Maryland to promote increased use of reference material and consistent naming;
- Provide a separate QC check of macroinvertebrate identification to supplement current evaluations of variability in field sampling and laboratory subsampling;
- Document questionable benthic taxonomic identifications (and their verification) and include in future QA reports;
- Revise fish key to account for new species (e.g., Blue Ridge sculpin) and problem identifications encountered by MBSS crews;
- Add a field audit of fish identification;
- Review qualitative physical habitat sampling variables (e.g., what is minimum, moderate or severe), provide additional training, and recommend grouping data into fewer categories for data analysis (e.g., group present and extensive);
- Improve methods to address habitat variables with the greatest discrepancies in order to increase precision, i.e., extent of bank erosion on left and right bank, eroded area on left and right bank, number of instream woody debris, number of dewatered woody debris, number of instream rootwads, number of dewatered rootwads, quality and extent of riffle/run, and embeddedness;
- Improve technique used to measure bank erosion and bar formation in future rounds of the MBSS. This could include the use of digital photographs taken at the site to resolve any discrepancies; and
- Improve installation of temperature loggers to ensure they will be measuring water temperature instead or air temperature. Alternatively, concurrently monitor air temperature in order to aid in distinguishing when the water logger is measuring air instead of water temperature.

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APPENDIX A

MBSS 2000 QC Notes

QC NOTE 1

1) Use UT as a designation for unnamed trib to...

2) Note that when an unsampleable culvert is in the segment, the total distance for the gradient CAN BE more than 75 meters. The same applies to gradient and straight line distance– something we need to be aware of in the field and also account for in range checking data, data analysis itself, etc. NANJ-112-R-2000 is an example of this– we should verify that calcs. for that site are correct as a check.

QC NOTE 2

Site	Comments
BRIG-111-R-2000	Added to reduce public lands bias
JONE-321-S-	Site eliminated as a sentinel station
JONE-109-S	Coordinates?
JONE-315-S	Coordinates?
LOCH-102-S	Coordinates?
LMON-122-T	I think this stream was relocated about 15 years ago by Lehigh cement
LMON-210-T	Right bank buffer = 0 (PV), but remoteness = 60 meters?
LMON-239-T	
LMON-240-T	QC site.....
LMON-252-T	Apparent discrepancy between 0 buffer (adj. Land cover= PV and LN, but buffer breaks on both sides in the form of pasture. If land cover next to stream was pasture, then PA is appropriate code- use buffer breaks to indicate additional sources (and severity) such as a paved road next to pasture.
LMON-421-T	Is nearest road 1000 meters? Seems far for Monocacy
UMON-101-R-2000	multi-flora rose prevented gradient and straight line measurement– they will do in summer
UMON-103-R-2000	Gradient estimated–thick multiflora rose
UMON-105-R-2000	Not a stream- coordinates above origin; reviewed twice by same reviewer
UMON-207-R-2000	Stream dried up in 1999. 50m buffer with OF and CP on either side– exactly at the 50m point on both? Should indicate land cover at 51 meters– was it still forest?
UMON-118-R-2000	Stream located totally under Rt. 15. And declared unsampleable. Need to do all sampling that can be done at each site. Try sampling fish with headlamps in summer. Reviewed twice by same reviewer
UMON-119-R-2000	Bare soil at the 51 meter mark on both sides of the stream?
UMON-124-R-2000	Unsafe to sample because of bull
UMON-128-R-2000	likely to be dry in summer

QC NOTE 3

SITE	COMMENTS
FIMI-103-R-2000	Will be dry in summer
FIMI-105-R-2000	Will be dry in summer
FIMI-106-R-2000	Overlaps with a 1995 MBSS site
FIMI-108-R-2000	Probably dry in summer
FIMI-109-R-2000	Same temp logger as FIMI-202– but not the same stream order. Need explanation- maybe ok if in close proximity, same land use, etc.
CASS-102-R-2000	Known to be acidic and fishless
CASS-109-R-2000	QC dup. Site
CASS-111-R-2000	Probably dry in summer
MARS-205-R-2000	CP and RR exactly 51 meters from stream?

MARS-121-R-2000	NOT SAMPLED– Permission obtained from PEPCO but owned by Allegheny Power- treated as a “no”
LTON-102-R-2000	Dry in summer
LTON-113-R-2000	Errors on permission sheet but able to convince landowner to let us sample
PRWA-104-R-2000	PV exactly 51 meters from right bank?
PRWA-106-R-2000	CP and RR exactly 51 meters from stream?
PRWA-107-R-2000	Unsampleable– underground in small culvert
PRWA-115-R-2000	Dry streambed, not sampled
PRWA-118-R-2000	Dry streambed
LIBE-202-R-2000	FW Fisheries sample site?
LIBE-207-R-2000	Landowner says it’s a bog turtle area; 50 m buffer on left bank– PA at 51 meters exactly?
LIBE-111-R-2000	Distance to nearest road = 0, but 20 m listed as buffer and no buffer breaks listed
LPAX-105-R-2000	Not Sampleable– Detention Pond
LPAX-115-R-2000	50 m buffer on both sides; adj land cover PV on left bank– at 51 m? If not, should be ‘FR’, not PV
LPAX-109-R-2000	Adj. Land cover listed as landfill (Marty should add ‘DU’ as a new code for dump/landfill) at 51 m exactly? LN at 51 m on other side?
LPAX-113-R-2000	Parking lot 10 m from stream- nearest road listed as 50 meters away– I changed to 10 m– parking lot should be considered same as road for access purposes
LPAX-204-R-2000	50 m buffer; HO at 51 m on both sides? Digits added to ‘Actual Coordinates’ section– do not do this
PATL-222-R-2000	50 m buffer with PK and HO on either side at 51 m mark– exactly? Always record land cover at 51 meter mark from stream if buffer is listed as 50 meters wide
PATL-118-R-2000	Digits added to ‘Actual Coordinates’ section– do not do this
PATL-115-R-2000	dry streambed
PATL-207-R-2000	Parking lot 0 m from stream- nearest road listed as 10 meters away– I changed to 0 m– parking lot should be considered same as road for access purposes
PATL-105-R-2000	buffer listed as 50 m, with PK at 51 m– true?
PATL-114-R-2000	50 m buffer on both sides; adj land cover PK on left bank– at 51 m? If not, should be ‘FR’, not PK
SWAN-110-R-2000	QC site; 50 m buffer on left bank; adj land cover LN on left bank– at 51 m? If not, should be ‘FR’, not LN; added golf course check box for land use

QC NOTE 4

CORS-102-R-2000	QC site
CORS-205-R-2000	possible marshwaders site
SEAS-120-R-2000	Probably dry in summer
UPCK-204-R-2000	Straight stream but not channelized; 0.17% gradient
UPCK-109-R-2000	QC site
UPCK-311-R-2000	Possible long anode site
UPCK-122-R-2000	Possibly dry in summer
UPCK-130-R-2000	Segment totally channelized with a 90 degree turn in the middle of the segment; I changed adj. Land cover from FR to PA because livestock have direct access to stream.
FURN- ___-C-2000	Coldwater IBI site project has been designated as “C”. Need to assign a segment number...I agree with stream order and number sampled as a convention
OCTO-___-C-2000	Needs a segment number assigned...
OCTO-___-C-2000	Needs a segment number assigned...

QC NOTE 5

ABPG-113-R-2000	Added a golf course box for LAND USE
ABPG-109-R-2000	Impoundment– not sampled
ABPG-108-R-2000	May be dry in summer- no flow in spring
ABPG-119-R-2000	Altitude may be off.
LOWI-103-R-2000	For ease in data entry, use 'buffer' instead of 'buff' in comments section
LOWI-104-R-2000	May need marshwaders for this site– 39 meter wide 1st order stream- one of those poorly defined channel sites
LOWI-105-R-2000	In a large impoundment– not sampleable
LOWI-113-R-2000	QC Sample; Use capital letters in Watershed Code-- I instead of 1 for the letter 'i'; make notation about chicken farm in comments section, not next to data block
LOWI-102-R-2000	Take care in printing each number, a '4' in the stream gradient section was easy to mis-interpret
WIRH-114-R-2000	Needs altitude filled in– no problem since we will be using topo numbers for altitude anyway
WIRH-108-R-2000	Use capital letters in Watershed Code
WIRH-111-R-2000	Use capital letters in Watershed Code; 24 meter wide 1st order stream– 6 anodes; needs altitude filled in– no problem.
WIRH-109-R-2000	CHANGED Watershed Code from WIHR to WIRH on both data sheets. Labeling error from Versar- on Marty's list to verify fixed. Correct chem and bug labels used for all sites in this watershed. Use capital letters in Watershed Code; needs altitude filled in– no problem.
WIRH-215-R-2000	6-7 Anodes; needs altitude filled in– no problem.
WIRH-220-S-2000	CHANGED Watershed Code from WIHR to WIRH on both data sheets. Need to correct chem and benthic data; possible marshwaders site; lat/lon coordinates on data sheet.
LPAX-408-R-2000	7+ anodes
GWYN-301-T-2000	***"T" designation should be changed to "X" on all data– benthic and water chemistry samples included– be sure to make the change when data is available***; needs altitude filled in– no problem; data sheet has lat/lon coords.
GWYN-302-T-2000	***"T" designation should be changed to "X" on all data– benthic and water chemistry samples included– be sure to make the change when data is available***; needs altitude filled in– no problem; data sheet has lat/lon coords.
LIBE-105-C-2000	needs altitude filled in– no problem; data sheet has lat/lon coords.
LIBE-101-C-2000	needs altitude filled in– no problem; data sheet has lat/lon coords.
LIBE-102-C-2000	needs altitude filled in– no problem; data sheet has lat/lon coords.
LIBE-103-C-2000	needs altitude filled in– no problem; data sheet has lat/lon coords.
LIBE-204-C-2000	This site has a migration barrier above it that isolates fish from Liberty Reservoir (brown trout, sunfish, bullhead); needs altitude filled in– no problem; data sheet has lat/lon coords.
NASS-108-S-2000	Sentinel site from the Pocomoke
NASS-301-S-2000	Another sentinel site from the Pocomoke; possible marshwaders site– many anodes and block nets
WYER-118-S-2000	Sentinel site-- use coords from prev. sampled site; QC site; needs altitude filled in– no problem
LOCR-102-S-2000	Sentinel site– lat/lon coords on data sheet– check coords from prev. sampled site; needs altitude filled in– no problem.
UPCK-113-S-2000	Sentinel site– lat/lon coords on data sheet; needs altitude filled in– no problem.
MONI-126-R-2000	2 parallel ditches; needs altitude filled in– no problem.

QC NOTE 6

CASS-307-R-2000	Stream reach sampled was ***4th order*** on the 250,000 scale file used for '95-97
MARS-224-R-2000	Site is ~10 m from Potomac River; verified with Matt Kline that road culvert is actually a concrete arch (C&O Canal passes over the stream)
MATT-320-R-2000	site was sampled to replace MATT-103-R-2000 (turned out to be tidal); ½ of site is in beaver pond, but sampleable in summer with partial dam removal
MATT-033-S-2000	SENTINEL SITE– Site coords on data sheet
TOWN-101-R-2000	Sampled this site in '95 MBSS
TOWN-102-R-2000	Probably dry in summer
TOWN-105-R-2000	**Straight line distance and slope measured over 86 meters of stream + culvert**; no temp logger– too shallow & no rootwads
TOWN-106-R-2000	Probably dry in summer
TOWN-110-R-2000	Tax map says state land– doesn't look like it...; probably dry by summer
TOWN-113-R-2000	Probably dry in summer; sampled this stream reach in '93 MBSS Pilot study
UMON-202-C-2000	COLDWATER SITE-- Site coords on data sheet
UMON-101-C-2000	COLDWATER SITE-- Site coords on data sheet
UMON-288-S-2000	SENTINEL SITE-- Site coords on data sheet
ANTI-101-C-2000	COLDWATER SITE-- Site coords on data sheet
WILL-301-C-2000	COLDWATER SITE-- Site coords on data sheet
WILL-102-C-2000	COLDWATER SITE-- Site coords on data sheet; 4th ranked vegetation type on left bank is '1' (or similar) – not one of the choices– check with Matt Kline
SAVA-204-C-2000	COLDWATER SITE-- Site coords on data sheet
SAVA-202-C-2000	COLDWATER SITE-- Site coords on data sheet
SAVA-101-C-2000	COLDWATER SITE-- Site coords on data sheet
SAVA-203-C-2000	COLDWATER SITE-- Site coords on data sheet
SAVA-225-S-2000	SENTINEL SITE-- Site coords on data sheet
SAVA-159-S-2000	SENTINEL SITE-- Site coords on data sheet
SAVA-276-S-2000	SENTINEL SITE-- Site coords on data sheet; about 150-200m downstream from original random site
YOUG-101-C-2000	COLDWATER SITE-- Site coords on data sheet
YOUG-202-C-2000	COLDWATER SITE-- Site coords on data sheet
YOUG-203-C-2000	COLDWATER SITE-- Site coords on data sheet
YOUG-432-S-2000	SENTINEL SITE-- Site coords on data sheet; about 800 m upstream from previously sampled random site (to be above hatchery)
LYOU-101-C-2000	COLDWATER SITE-- Site coords on data sheet; known water withdrawals on this stream
PRUN-302-C-2000	COLDWATER SITE-- Site coords on data sheet; sampled same site in 1996; lime doser upstream ~ 2miles; site is ~30 meters from North Br. Potomac River– possible river influence on spp composition?
PRUN-101-C-2000	COLDWATER SITE-- Site coords on data sheet;
WCHE-086-S-2000	SENTINEL SITE– Site coords on data sheet; sampled same site in 1997
NANJ-331-S-2000	SENTINEL SITE– Site coords on data sheet; sampled same site in 1995
PTOB-002-S-2000	SENTINEL SITE– Site coords on data sheet; STREAM WENT DRY LAST SUMMER
ZEKI-012-S-2000	SENTINEL SITE– Site coords on data sheet
STCL-051-S-2000	SENTINEL SITE– Site coords on data sheet; unsure of permission status
PAXL-294-S-2000	SENTINEL SITE– Site coords on data sheet; no flags evident from '97 MBSS
FIMI-207-S-2000	SENTINEL SITE– Site coords on data sheet; about 300 m upstream from a 1995 MBSS site
PRLN-626-S-2000	SENTINEL SITE– Site coords on data sheet; about 300m downstream from 1996 MBSS site
PATL-R-109-2000	QC Site; NEED TO ADD "QUARRY" to adj land use choices

PATL-R-202-2000	1st and 2nd reviews not signed off; beaver pond-- benthic sample taken from 200 m downstream (not in segment and not labeled as such)
ABPG-R-214-2000	Beaver dam– not sampleable for benthos and habitat assessment
LPAX-206-R-2000	Very nasty stream– landfill and development upstream- smells. ADD LANDFILL CATEGORY TO ADJACENT LAND USE
LPAX-401-R-2000	big site– needs two crews. Question of how to do straight line distance when there are major braids– DISCUSS AT SUMMER TRAINING
BELK-301-X-2000	CHANGED 'T" to "X" in "TYPE" because this is not a randomly selected site in one of the targeted watersheds. ALL OTHER DATA NEED TO BE CHANGED TO REFLECT THIS; ACOE SITE--site coords on data sheet
PRUT-201-X-2000	CHANGED 'T" to "X" because this is not a randomly selected site in one of the targeted watersheds. ALL OTHER DATA NEED TO BE CHANGED TO REFLECT THIS; missing gradient, will be done in summer; take elevation from topo; ACOE SITE--site coords on data sheet
ANAC-301-X-2000	CHANGED 'T" to "X" because this is not a randomly selected site in one of the targeted watersheds. ALL OTHER DATA NEED TO BE CHANGED TO REFLECT THIS; take elevation from topo; ACOE SITE-- site coords on data sheet
ANAC-302-X-2000	CHANGED 'T" to "X" because this is not a randomly selected site in one of the targeted watersheds. ALL OTHER DATA NEED TO BE CHANGED TO REFLECT THIS; take elevation from topo; ACOE SITE- site coords on data sheet

QC NOTE 7

MATT-115-R-2000	Meter Calibrations not signed for– verify completed in cal log book; beaver dam within segment but easy shocking
MATT-117-R-2000	Site is between 2 large clearcuts
MATT-212-R-2000	Matt was unsure who owned property
MATT-108-R-2000	Same stream as MATT-105- this one flows thru 2 huge crop fields; meter calibrations not signed for– verify in cal log book
MATT-109-R-2000	Substrate mostly cobble/gravel even though its coastal plain
MATT-105-R-2000	Few fish even though excellent habitat
MATT-104-R-2000	820 g on 2nd pass fish, 165 on 1st– was weight due to the eel being large?
PTOB-002-S-2000	anomaly problems with blacknose dace at this site (cysts/tumors)
PAXL-294-S-2000	Meter calibrations not signed for– verify in cal log book
NANJ-119-R-2000	Stream originates in public land
NANJ-206-R-2000	Meter calibrations not signed for– verify in cal log book
WILL-102-C-2000	Recent timber operation upstream in watershed- no longer runs clear during storms; potential rainbow spawning stream (no YOY and next stream downstream has been stocked)
CASS-101-R-2000	Meter calibrations not signed for– verify in cal log book; minnow movement noted during blocknet installation
NANJ-205-R-2000	Meter calibrations not signed for– verify in cal log book; no length recorded for chain pickerel (checkcrib sheet); see photos of site!!
NANJ-111-R-2000	No flow- no fish (YOY mudminnow <30mm though); possibly overlaps an MBSS site from '95
NANJ-115-R-2000	huge clear-cut beyond buffer; forgot 'Eastern' in front of box turtle
NANJ-109-R-2000	Nearly dry- no fish; meter calibrations not signed for– verify in cal log book
STMA-110-R-2000	Meter calibrations not signed for– verify in cal log book
STMA-113-R-2000	May overlap an MBSS random site from '95
STMA-101-R-2000	Stream begins within stormwater collection pond- no flow and no fish
STMA-104-R-2000	**Exotic plants section not filled out–** collect this data (site is right next to road) when doing rest of St. Marys site templogger pickups
STMA-116-R-2000	Dry in summer, but herps listed as sampleable and no data sheet exists. Also, 4 pages indicated on the Page__ of__ and only one found...

STMA-112-R-2000	Meter calibrations not signed for– verify in cal log book;
STMA-108-R-2000	PH<5
STCL-051-S-2000	Heavy t-storm in last 24h but crystal clear!

QC NOTE 8

SAVA-202-C-2000	Blacknose dace total for 1st pass appears to be 101 but is hard to read– verify if possible from crib sheet
SAVA-101-C-2000	Meter Calibrations not signed for– verify completed in cal log book
UMON-202-C-2000	Is this a Coldwater site and not a random one? If not, 'C' needs changed to an 'R'. One brook trout had pop eye; don't need to delineate 1st pass from 2nd pass gamefish
UMON-119-R-2000	73 fish total for both passes– 49 of which were trout
UMON-229-R-2000	Meter Calibrations not signed for– verify completed in cal log book; unknown minnow retained that needs ID.
UMON-101-R-2000	Massive multiflora rose site– 3 hours to cut enough to sample
UMON-132-R-2000	Mostly dry
UMON-128-R-2000	Dry
UMON-103-R-2000	Meter calibration by 'Kraut'-- who is this?; in 'Flow' section, no need to write a 0 before a whole number in the depth category- ok to leave a blank
UMON-304-R-2000	Three rock bass of 11 had only one eye; all trout appeared to be stocked
UMON-115-R-2000	No fish– an obvious reason? Maybe small enough to dry up in some years and steep enough to have migration blocks?
UMON-207-R-2000	20 fish spp but low numbers of each; EMBEDDEDNESS NOT FILLED OUT– NEED TO RETURN TO SITE AND DO
UMON-134-R-2000	All fish captured were small YOY
UMON-288-S-2000	All forested upstream- sentinel site. Brook trout only here.
PRWA-117-R-2000	Dry
CASS-106-R-2000	
MARS-205-R-2000	Herpetofauna section left blank– were none observed, no attempt made, or forgot to fill in what was there? No rain in over a week but still has turbidity
ANTI-101-C-2000	Tons of brook trout

QC NOTE 9

LIBE-203-R-2000	Several spelling errors with fish; extra numbers next to anodes/unit boxes should be scratched out to make data entry less confusing; be consistent with use of diagonal line through zeros.
LIBE-104-R-2000	Comments section should be printed to improve legibility
LIBE-113-R-2000	Probable reservoir influence on what fish were caught
LIBE-117-R-2000	The last lateral location in the flow section hard to read because of erasure– use lineout and arrow to show correct number
LIBE-110-R-2000	Herp retained– I didn't leave a way to indicate that it was preserved, only have Photo and Not Retained. **Decision made with Marty is that we should write in the number of individuals retained (up to 9) in that box, still using 'P' and 'N' for photographed specimens and those that were released without a photo**.
LIBE-303-R-2000	Glassy darter in the Patapsco!; don't need to delineate 1st pass from 2nd pass gamefish; some numbers in flow section hard to read because of smearing.
LIBE-103-C-2000	QC visit site
LIBE-102-C-2000	Letters next to anodes/unit boxes should be scratched out to make data entry less confusing
LIBE-204-C-2000	QC Visit; skipped to 2nd column for second pass gamefish lengths– no need to do this

LIBE-318-R-2000	Common shiner listed as "1/4 with black spot in anomalies section, but listed as "N" for no unusual anomalies. I changed to "Y" for yes.
LIBE-105-C-2000	Extraneous weight info. Written on fish length data sheet– use crib sheet for this.
LIBE-202-R-2000	Landowner request for data

QC NOTE 10

LTON-114-R-2000	No fish site– reasons unclear; instream habitat score is either 16 or 10– cannot discern; deep pool section of stream character not filled out (Max depth listed as 0.5 meters)
LTON-102-R-2000	In bank erosion section, use 0's for severity and eroded area if no erosion is present
LTON-119-R-2000	Sampled same reach (~200m downstream) in '95 as a degraded (i.e., not random) site.
FIMI-207-S-2000	Please fill in Y or N for unusual anomalies section for each species- don't draw a line
FIMI-202-R-2000	probably dries up during drought summers
FIMI-106-R-2000	Site overlaps with a site from 1995
FIMI-109-R-2000	Site FIMI-110-R-2000 is ~450 m upstream
FIMI-110-R-2000	YOY creek chub and blacknose dace present, but less than 30mm long
FIMI-103-R-2000	Dry streambed
TOWN-113-R-2000	Intermittent and no flow- part of Maple Run watershed that dries up each summer; sampled very near site during '93 Pilot study
TOWN-102-R-2000	sections of stream were dry below and at top end of segement– this watershed goes dry in most years naturally
TOWN-106-R-2000	Dry– naturally
CASS-111-R-2000	Mine seep upstream (apparently minor at time of sampling based on low conductivity, but no fish); 10 m of segment was dry; BEAVER POND BOX NOT FILLED IN
CASS-105-R-2000	No fish– conductivity elevated (check lab chem results for AMD influence)
CASS-109-R-2000	No flow in site; WATER CLARITY ON 2nd PASS NOT FILLED IN; battery died between 1st and 2nd pass, used y-connection to keep two anodes on 2nd pass (PK modified shock times to reflect this); WERE COMMON SHINER LOOKED AT CLOSELY TO ENSURE THEY WEREN'T STRIPED SHINER?
CASS-113-R-2000	NO INDICATION OF WHETHER FISH WERE RETAINED, and striped shiner was collected (1)
CASS-102-R-2000	No fish- pH and conductivity low (probably acid dep killed); pencil in flow section is smeared– difficult to copy
YOUG-432-S-2000	Sentinel site; DNR fish hatchery about 200 m downstream
YOUG-203-C-2000	EXOTIC PLANTS SECTION NOT FILLED OUT– NEED TO RETURN TO SITE (TEMPLOGGER PICKUP) AND GET THIS INFO; small lake ~2 miles upstream
SAVA-276-S-2000	Sentinel site
WILL-301-C-2000	Known AMD influence, but still lots of brook trout
PRUN-101-C-2000	Potomac River confluence is 10 m from bottom of site
PRUN-302-C-2000	Site was sampled in '96 MBSS; it is ~ 50 m from Potomac River confluence; lime doser upstream about 2 miles
UPCK-109-R-2000	Writing for fish species is too small- need to write BIGGER
UPCK-115-R-2000	Much SAV– difficult to sample fish (depletions looked ok and abundance seemed reasonable though)
UPCK-119-R-2000	Writing for fish species blurry
UPCK-130-R-2000	Standing water and DO<1– no fish
CORS-107-R-2000	Site ~1/4 mile above CORS-108-R-2000; SEVERITY OF BANK EROSION LISTED AS 'M'-- SHOULD BE A NUMBER– LOOK AT AND RECORD WHEN TEMP LOGGER IS RETRIEVED

SEAS-120-R-2000	Shallow standing pools; DO<3; meter calibration not signed for– CHECK CALIBRATION LOG TO VERIFY THAT INSTRUMENTS WERE CALIBRATED
BRIG-111-R-2000	First pass number for creek chub difficult to read– determined to be 105 based on crib sheet
BRIG-131-R-2000	QC Site
BRIG-218-R-2000	Writing too small on gamefish sheet– looks like brown 'twit'

QC NOTE 11

PRET-108-R-2000	Last digit on thalweg velocity at 25 meters is not clear
PRET-110-R-2000	Erase or scratch out writing next to number of anodes box– may be confusing to data entry people
PRET-113-R-2000	The number for time at end of 2nd pass is difficult to read
SBPA-109-R-2000	Big flow change at site during sampling, probably from previous night's rain
LMON-101-T-2000	Use correct common name for herps
LMON-202-T-2000	Some smearing of writing on fish data sheet- more difficult to obtain legible photocopies that way
LMON-203-T-2000	Heavy rain during 2nd pass
LMON-220-T-2000	Heavy rain at end of 2nd pass– water quality measured 5 days later at baseflow
LMON-237-T-2000	QC visit; record abundance site (Carrroll Creek)
LMON-240-T-2000	QC visit; in bank erosion section, 'M' used instead of a number to indicate severity (M could be Minor or Moderate)**–NEED CLARIFICATION– LOOK AT DURING TEMPLOGGER RETRIEVAL**

QC NOTE 12

WIRH-215-R-2000	QC visit site; tessellated darter misspelled; **three digits needed for LWD and rootwad counts (need to modify datasheet and entry program to reflect this)**; writing smeared but readable on flow section (won't copy well)
WIRH-109-R-2000	No fish and no flow– pH < 5 and essentially 0 DO may explain lack of fish
LOWI-102-R-2000	QC visit site;
MATT-305-X-2000	ACOE site; good habitat & chem but few fish
ANAC-302-X-2000	ACOE site- has shopping carts and a motorcycle in segment (& 28 spp of fish...)
NASS-108-S-2000	QC visit site
SWAN-106-R-2000	No flow and small– only 1 fish taken
ABPG-302-R-2000	Turbid– maybe from muskrat activity (beaver ponds upstream were clear)
UPCK-113-S-2000	chicken manure pile next to stream– this is a sentinel site...
GWYN-301-X-2000	central stonerollers had many anchor worms– unusual; **flow section smeared and hard to read some numbers**
SBPA-329-R-2000	QC visit site
SBPA-424-R-2000	QC visit site; visited in AM (too turbid from animal activity)- cleared up by visit in PM and sampled; few fish for size of stream– Serrengeti-like run in most of segment; **USED 21 entries for flow– will data entry handle ok?**
UPCK-311-R-2000	**Lesions found on many fish**
UPCK-229-R-2000	Tidally influenced; qualitative electrofishing conducted
LOCH-120-S-2000	Sentinel site; **last lateral location for flow was listed as 0.00 meters– in error– changed to 1.00 meters**
LOCH-102-S-2000	Some writing in flow section too light- won't copy well
JONE-109-S-2000	Sentinel site with only blacknose dace
OCTO-102-C-2000	Coldwater index development site– only 1 brown trout found
FURN-101-C-2000	Coldwater index development site– no trout found

QC NOTE 13

MATT-320-R-2000	Added missing zeros in the 'begin 1st pass' boxes
MATT-210-R-2000	Site MATT-216-R-2000 is ~500 m upstream– site is much more degraded than the upper one
STMA-202-R-2000	very difficult access; flow tough to get because deep and slow
NANJ-308-R-2000	'Pickerel' spelled wrong
FIMI-407-R-2000	deleted eastern box turtle from herp box because it was an old shell (population may no longer exist)- added to comments section
FIMI-401-R-2000	QC visit site; DNR Parks truck drove through segment during 1st pass sampling and back across during 2nd pass sampling (temporarily reduced visibility)
FIMI-105-R-2000	Cow pasture stream;
SAVA-225-S-2000	Sentinel site in upper Savage River– brown trout present
TOWN-110-R-2000	Stream is intermittent-= dries up below 0 m mark; very little flow
TOWN-104-R-2000	30 m of segment was dry and only 1 fish collected; N. fence lizard collected– we need one for training collection so please retain; site TOWN-101-R-2000 is ~ 500 m downstream
TOWN-101-R-2000	almost no flow
LTON-108-R-2000	Stream flows through wetland- substrate highly embedded
LTON-113-R-2000	Heavy silt deposits
PRWA-122-R-2000	Pond approx. 1/4 mile above site; stream possibly dry or nearly so during previous week
PRWA-104-R-2000	Very little flow; all fish very small– probably YOY; lies in median strip of I-70
PRWA-103-R-2000	Recent logging adjacent to stream

QC NOTE 14

UPCK-122-R-2000	tough to sample because of mud/silt, still had good depletions though
LOCH-209-S-2000	Golf course site; small question mark next to fish # 24 (listed as a 72 mm largemouth bass) on gamefish length data– what was this for? Also, datasheet from 1996 sampling included in the package of data sheets– was this reach also sampled in 1996?
BRIG-123-R-2000	Small stream but 18 species of fish
LPAX-401-R-2000	~8 square meters too deep to sample (2.5 meters)- rest ok
LOWI-104-R-2000	First order stream that required 5 shockers and was 20 meters wide

QC NOTE 15

STMA-JA1-X-2000	ACOE study; green snake species not confirmed and not retained
STMA-HR2-X-2000	ACOE study
STMA-HR1-X-2000	ACOE study
STMA-JC1-X-2000	ACOE study
STMA-JA2-X-2000	ACOE study
STMA-PB1-X-2000	ACOE study

QC NOTE 16

LMON-421-T-2000	Sample 48 hours outside of Summer Index Period
LOWI-113-R-2000	Mega SAV & EAV- difficult to net fish
STMA-USM-X-2000	ACOE site

QC NOTE 17

WCHE-086-S-2000	Two blue crabs caught in segment
FIMI-108-R-2000	Dry stream

FIMI-404-R-2000	For repeated gamefish of all same species, draw line with arrow down the page
YOUG-202-C-2000	all trout were wild spawned
PRWA-106-R-2000	No fish even thought max depth was 42 cm
MARS-210-R-2000	Greenside darter listed as 'greenside dax' by my interpretation- confirmed by M. Kline and corrected
MARS-224-R-2000	Part of segment under C&O canal; substrates concreted
UMON-322-R-2000	Flow section had some smeared numbers- readable but not great
UMON-310-R-2000	Heavy silt due to cattle access; **skeletal deformities in 3 different species** (one of each)
TOWN-408-R-2000	Why wasn't comely shiner retained- I don't recall seeing any from other sites this year; same for silverjaw- isn't this new for upper Potomac basin?
TOWN-409-R-2000	Braided channel- bank erosion, etc. measured over 150 m
TOWN-412-R-2000	Landowner would not allow 2nd pass to be done (inform Versar about situation); Length for second smallmouth bass on gamefish length data sheet is not legible (2nd digit)-- looks like 264 mm; missing some habitat data as well

QC NOTE 18

PRET-101-R-2000	Needs stream name added; is stream bottom earthen? If not, leave "bottom" column blank under channelization
PRET-102	Stream name missing
PRET-108	Stream name missing
PRET-110	Stream name missing
PRET-111	Stream name missing
PRET-112	Stream name missing
PRET-113	Stream name missing; site ended up on Swam property as well- need to get info on adjacent landowners when near boundary; site with thorn-bearing caddis
PRET-214	Stream name missing
SBPA-207	Stream name missing
SBPA-424	bottom=earthern berm?
SBPA-103	Stream name missing
SBPA-104	Stream name missing
SBPA-105	Stream name missing; 4 meter gradient with 50 m straight line distance
SBPA-108	Stream name missing
SBPA-109	Stream name missing
SBPA-113	Stream name missing
SBPA-114	Not a stream
BRIG-115	Stream name missing
BRIG-218	Stream name missing
BRIG-105	Stream name missing
BRIG-123	Stream name missing; 1800 meter walk???
BRIG-131	Stream name missing
BRIG-132	Stream name missing

APPENDIX B

QA/QC Water Quality Report by

University of Maryland Center for Environmental Science

Appalachian Laboratory

Summary of Quality Assurance/Quality Control Results from Spring 2000 Water Chemistry Analysis for the Maryland Biological Stream Survey

April 2001

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Introduction

The primary objective of a good laboratory quality assurance plan is to ensure the quality of the data generated by the laboratory. Each method of analysis must then employ specific quality control steps to ensure data quality. To ensure attainment of the quality assurance objectives, standard operating procedures have been implemented that detail the requirements for the correct performance of analytical, or laboratory, procedures. The quality of all data generated and processed during the Spring 2000 Maryland Biological Stream Survey has been monitored for both precision and accuracy. The internal quality assurance/quality control protocols for chemical analysis followed guidelines from the "Handbook of Methods for Acid Deposition Studies: Laboratory Analyses for Surface Water Chemistry" (EPA, 1987).

Precision was determined by measuring the agreement among individual measurements of the same property, under similar conditions. Precision was assessed through the analysis of laboratory duplicates, or splits. The degree of agreement between replicates can be expressed as the percent relative standard deviation (RSD):

$$Percent\ RSD = \frac{SD}{X} X\ 100$$

Accuracy is defined as a measure of the closeness of an individual measurement to the true or expected value. Analyzing a reference material, or quality control check solution (QCCS), of known concentration is a method of determining accuracy. QCCS were independently made and analyzed after calibration, at specified intervals during sample analysis, and at the conclusion of sample analysis to ensure accurate measurement throughout analysis.

Deionized water blanks served as a check of laboratory-induced contamination. Laboratory blanks were analyzed at predetermined intervals as outlined in the standard operating procedures for each analyte.

Sample spikes were used with most of the analytical techniques to determine whether sample matrix affected analytical accuracy. A known concentration of analyte was added to about 15% of the samples. Both the spiked and unspiked samples were then analyzed. Percent recovery was calculated using the following equation:

$$\%\,SpikeRecovery = \frac{spikedsample - routinesample}{spikeamount(mg/L)} X\ 100\%$$

Percent recovery calculated for sample spikes should be within 15% of 100%.
An additional method employed by the laboratory to demonstrate quality of the chemical data was routine analysis of a field natural audit sample. The laboratory also participates annually in an inter-laboratory audit program.

The quality assurance plan in the analytical laboratory has yielded excellent results. A detailed description of the calibration and a summary of the quality control procedures and results for each analysis performed

by the analytical laboratory at the University of Maryland Center Environmental Science Appalachian Laboratory in support of the 2000 Maryland Biological Stream Survey follows.

Analytes

Closed pH

The pH meter was calibrated using a set of three buffers with pH values of 4.00, 7.00 and 10.00. A quality control check solution (QCCS) with a theoretical pH value of 5.00 was then used to verify calibration. The measured value of the QCCS is required to be within 0.05 pH units. The QCCS was analyzed using the same procedures as for routine samples. If the QCCS was not within the acceptable range, then the solution was remade and analyzed again. If it failed to pass the second time, the meter was re-calibrated, and all samples that were measured since the last acceptable QCCS were re-analyzed. The average pH of all pH 5.00 QCCS analyzed in spring of 2000 was 4.98 (Table 1).

A laboratory blank was analyzed with each batch of samples. The average pH value for the lab blank was 5.52 (Table 2). The pH of laboratory blanks can be variable due to the nature of the matrix but it should typically be between 5.40 and 6.00, which brackets the normal equilibrium value of carbon dioxide and water.

Laboratory duplicates for closed pH were analyzed every ten samples. Acceptable precision criteria for pH require that duplicates be within 0.10 pH units of the routine sample analysis. Analysts achieve an average difference of 0.01 pH units (Table 3), which is within the acceptable precision limits for laboratory duplicate analysis for pH.

Acid Neutralizing Capacity (ANC)

Acid neutralizing capacity (ANC) was measured using the acidimetric Gran titration technique with electrometric pH detection. The pH meter used for the titration was calibrated using a set of two pH buffers that bracketed sample pH. A QCCS with a theoretical value of 5.00 was used to verify calibration. Any time that the QCCS was outside of the acceptable limits, the meter was re-calibrated and the QCCS was subsequently re-analyzed. The normality of the acid titrant was also cross-checked on a routine basis to verify method accuracy.

Prior to sample analysis a deionized water lab blank and sodium carbonate standards with a theoretical ANC of 200 or 50 µeq/L were analyzed to verify method and analyst accuracy. Standards with ANC's of 50 and 200 µeq/L were chosen because they most closely reflected the expected median sample median ANC. The average ANC of the 50 µeq/L QCCS was 49.2 µeq/L and the average for the 200 µeq/L QCCS was 196.7 µeq/L (Table 1). The accuracy goal for analysis of the QCCS for ANC is $\pm$ 5%. Whenever the QCCS was outside of the acceptable range, it usually indicated that the acid titrant was due to be re-standardized. The titrant was re-standardized and any samples from that batch were re-analyzed. The mean ANC for all blanks analyzed was 1.2 µeq/L, which is well below the acceptable limit of 10 µeq/L, and indicates an overall lack of contamination (Table 2). Laboratory duplicate analysis also yielded excellent precision results for ANC (Table 3).

Specific Conductance

Specific conductance was measured using a conductivity cell and meter with temperature compensation to 25°C. Before sample analysis, the conductivity meter was subjected to an electronics check over the range of 1.0 µS/cm to 1000 µS/cm. This was used to verify that the meter was operating correctly. A series of calibration check solutions that bracketed the expected conductance values were then made and measured to check the calibration of the conductivity cell. A laboratory blank was also analyzed prior to sample analysis. If the initial conductance values of all of the calibration check solutions and the blank were within acceptable limits, sample analysis could proceed. The 74 µS/cm check solution was also measured every ten samples and all calibration check solutions were re-analyzed at the conclusion of sample analysis (Table 1). At the conclusion of sample analysis, if any of the sample measurements were higher than the highest calibration check solution, a higher calibration check solution was prepared and analyzed to verify the linear range of the technique. An average laboratory blank of 0.6 was well below the acceptance criteria of 1 µS/cm (Table 2). Laboratory duplicates were measured every ten samples and were required to be within one percent RSD. The average duplicate precision for specific conductance was 0.68 % RSD (Table 3).

Major Anions

Anions were measured using ion chromatography. Calibration for chloride, nitrate-nitrogen, and sulfate were conducted over at least a six point range, bracketing the expected concentrations of the ions of interest. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

A QCCS was measured at the beginning and the end of sample analysis. The QCCS had a theoretical value 2.0 mg/L. The mean values for the anion QCC were all within the recommended EPA quality assurance criteria for these analytes (Table 1). A laboratory blank was analyzed at the beginning of analysis. All blanks analyzed were below the detection limit for all three analytes (Table 2). Lab duplicate analysis was conducted approximately every ten samples. Duplicate laboratory analysis yielded an average percent RSD of 0.62 for chloride, 0.86 for nitrate-nitrogen, and 0.68 for sulfate (Table 3). These values verify that precision for the method was within acceptable limits. Matrix spike results for major anions suggest that sample matrix did not interfere with the analytical technique (Table 6). Average percent recovery values were within 15%.

Dissolved Organic Carbon

DOC was measured using the UV-persulfate oxidation methods. Calibration was conducted over a five point range, bracketing the expected DOC concentrations. Sample concentration was computed from instrument response using a calibration curve. The linear range of the calibration curve had to be greater than 99.5 percent before sample analysis could commence.

Check solutions were measured at the beginning of sample analysis and once every 20 samples. The solutions had theoretical values of 2 and 10 mg/L DOC. The average values for all check solutions analyzed were 2.10 mg/L for the 2 QCCS and 9.88 for the 10 QCCS (Table 1). Laboratory blanks were also well

within acceptable limits for DOC (Table 2). Laboratory duplicates were analyzed once per sample batch and yielded a precision value of 3.30 percent RSD (Table 3). The acceptable limit of precision for DOC analysis is ten percent RSD.

Inorganic Nutrients

Nutrients were measured using colorimetric flow injection analysis techniques. Calibration for nitrite-nitrogen, ortho-phosphate, and ammonia were conducted over at least a five point range, bracketing the expected concentrations of the ions of interest. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

A QCCS was measured at the beginning and end of sample analysis, as well as at regular intervals. The QCCS had a theoretical value 0.05 mg/L. The mean values for the nutrient QCC were all within the recommended EPA quality assurance criteria for these analytes (Table 1). A laboratory blank was also analyzed at the beginning of analysis. All blanks analyzed were below or close to the detection limit for all three nutrients (Table 2). Lab duplicate analysis was conducted approximately every ten samples. Duplicate laboratory analysis yielded an average relative difference of <0.000 for nitrite, 0.001 for ortho-phosphate and 0.003 for ammonia (Table 3). These values verify that precision for the method was within acceptable limits. Matrix spike results for inorganic nutrients verify that sample matrix did not interfere with the analytical technique (Table 6). Average percent recovery values were within 15%.

Total Dissolved Nitrogen

Total dissolved nitrogen was measured on filtered samples using an in-line heat- and uv-assisted alkaline persulfate digestion technique. Calibration for total nitrogen was conducted over a five point range with nitrate standards that bracketed the expected sample concentrations. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

A QCCS was measured at the beginning and end of sample analysis, as well as at regular intervals. The QCCS had a theoretical value 0.5 mg/L and was prepared from a nitrite stock solution. By using nitrite for the source of the QC, this enabled the analyst to track cadmium column performance. The mean value for the nitrite QCC was within the recommended EPA quality assurance criteria (Table 1). Since this technique involved digestion of all nitrogen forms to nitrate, a digestion check solution of 0.9 mg/L was prepared from an ammonia standard as a check of digestion efficiency. The mean value for the digestion check standard was 0.829 mg/L, which is within recommended EPA QA criteria. A laboratory blank was also analyzed at the beginning of analysis (Table 2). Lab duplicate analysis was conducted approximately every ten samples. Duplicate laboratory analysis yielded an average precision of 1.74 % RSD (Table 3). Average percent recovery values for matrix spikes for TDN was 96.9 %, which is within the recommended 15% (Table 6).

Total Dissolved Phosphorus

Total dissolved phosphorus was measured on filtered samples using manual acidic persulfate digestion technique followed by colorimetric measurement by flow injection analysis. Standards, QC samples, blanks, and samples were all subjected to the same digestion procedure. Calibration for total phosphorus was conducted over a five point range with phosphate standards, bracketing the expected sample concentrations. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

A QCCS was measured at the beginning and end of sample analysis, as well as at regular intervals. The QCCS had a theoretical value 0.05 mg/L and was prepared from an independent phosphate stock solution. The mean values for the phosphate QCCS was well within the recommended EPA quality assurance criteria (Table 1). Since this technique involved conversion of all forms of phosphorus forms to phosphate for analysis, a digestion check of 0.2 mg/L was prepared from a sodium pyrophosphate standard as a check of digestion efficiency. The mean value for the digestion check standard was 0.183 mg/L, which is within 10% of the actual value. A laboratory blank was also analyzed at the beginning of analysis. All blanks analyzed were below or close to the detection limit (Table 2). Lab duplicate analysis was conducted approximately every ten samples. Duplicate laboratory analysis yielded an average percent RSD of 2.95(Table 3). These values verify that precision for the method was within acceptable limits. Average percent recovery values for matrix spikes for TDP was 98.4 %, which is within the recommended 15% (Table 6).

Particulate Phosphorus

Particulate phosphorus was collected on glass fiber filters. The samples were ashed at 550°C and digested in 1.0 N hydrochloric acid. The supernatant was then analyzed for phosphate using colorimetric measurement by flow injection analysis. Calibration for particulate phosphorus was conducted over a five point range with phosphate standards, bracketing the expected sample concentrations. Sample concentration was computed using peak area. The linear range of the calibration curve had to greater than 99.5 % before analysis of samples could be performed. Calibration plots of each analysis batch are archived at the Appalachian Laboratory.

An independent 0.10 mg/L phosphate QCCS was measured at the beginning and end of sample analysis, as well as at regular intervals. The mean value for the phosphate QCC was within the recommended EPA quality assurance criteria (Table 1). Blank filters that had been carried through the same preparation procedure were also analyzed. The mean blank filter value for each analysis run was subtracted from each sample to correct for the filter. Lab duplicate analysis was conducted approximately every ten samples and yielded excellent precision results (Table 3). Average percent recovery values for matrix spikes for particulate phosphorus was 102.7 %, which is within the recommended 15% (Table 6).

Particulate Nitrogen

Particulate nitrogen was measured using 25-mm diameter glass fiber filters. The filters were combusted in tin capsules at 900°C, which converts all particulate nitrogen to nitrogen oxide. The nitrogen oxides are then converted to molecular nitrogen and analyzed by thermal conductivity detection. The instrument was calibrated using approximately four separate acetanilide and/or atropine standards at weights expected to bracket instrument response for samples. Blank filters that had been carried through the same preparation procedure were also analyzed. The mean blank filter value for each analysis run was subtracted from each sample to correct for the filter concentration.

Acetanilide standard checks were analyzed between every 15-20 samples and at the end of each run. The average composition for nitrogen was 10.13%, which is within 10% of the actual composition value of 10.36% (Table 1). Lab duplicate analysis also yielded excellent precision results (Table 3).

Collection and Analysis of Natural Audit Sample

Natural audit samples are another useful part of a comprehensive Quality Assurance Plan. Because they are collected from streams, they are more representative of the actual sample matrix than a manufactured calibration check solution. In January of 1997, a field natural audit sample was collected from Upper Big Run in the Savage River State Forest in order to establish an internal audit sample (FNBR001). Approximately 50 liters of sample were filtered using a 0.45 µm filter capsule and a Masterflex pump. The sample was returned to the Appalachian laboratory where it was refrigerated for approximately 20 days and periodically check for stability by analyzing sample ANC. Once the sample was stable, it was poured off into 500 mL aliquots. The audit samples are stored in the dark at 4°C and are analyzed periodically for all analytes except closed pH and aluminum. Although there are no actual right or wrong results for any of the analytes, as when a known QCCS is measured, variations in analyte concentration can help determine or diagnose any sources of analytical error. They are especially useful as a diagnostic tool when any changes in the operating conditions of an instrument (i.e., column or electrode replacement). Results from analysis of the audit sample verify the stability of the analytical results (Table 4).

Interlaboratory Audit

The laboratory also participates in the National Water Research Institute (NWRI) Ecosystem Interlaboratory Quality Assurance Program annually as an additional quality assurance measure. Twelve natural water samples were analyzed for the following analytes: open pH, specific conductance, DOC, ANC, nitrate-nitrogen, ammonia, total phosphorus, total nitrogen, sulfate, and chloride. Results from the Spring 2000 study were good with the laboratory receiving ideal ratings for six of the analytes (Table 5).

Table 1. Summary of QCCS analysis.

Analyte	Theoretical Value	Mean	N	Std. Dev.	Min.	Max.
Closed pH	5.00	4.98	129	0.02	4.95	5.02
ANC	200.0	196.7	35	6.5	185.6	213.2
	50.0	49.2	39	2.3	43.6	52.8
Conductance	14.7	14.8	34	0.43	13.4	15.8
	74.0	73.2	43	1.04	71.3	76.1
	147.0	145.0	34	2.23	140.1	149.1
Chloride	2.0	1.874	49	0.05	1.799	2.049
Nitrate-N	2.0	1.871	49	0.07	1.825	2.071
Sulfate	2.0	1.966	48	0.04	1.885	2.082
Nitrite-N	0.05	0.051	36	0.002	0.047	0.053
Ortho-phosphate	0.05	0.046	36	0.008	0.039	0.057
Ammonia	0.05	0.054	36	0.006	0.037	0.061
TDN	0.50	0.514	36	0.043	0.402	0.602
TDP	0.05	0.049	49	0.005	0.039	0.062
DOC	10.0	9.88	49	0.21	9.45	10.28
	2.0	2.10	48	0.12	1.86	2.42
PP	0.10	0.093	45	0.005	0.084	0.102
PN	10.36%	10.13	43	0.16	9.09	10.51

Table 2. Summary of laboratory blank analyses.

Analyte	Mean	N	Std. Dev.	Minimum	Maximum
Closed pH	5.52	47	0.19	5.29	6.15
ANC	1.2	33	2.7	-5.0	8.6
Conductance	0.6	18	0.2	0.3	0.9
Chloride	0.003	20	0.01	0	0.06
Nitrate-N	0	20	0	0	0
Sulfate	0	20	0	0	0
Nitrite-N	0	21	<0.001	-0.0002	0.0001
Ortho-PO4	0.0019	21	0.002	-0.0013	0.0071
Ammonia	-0.0009	21	0.010	-0.0192	0.0192
TDN	0.0178	20	0.062	-0.080	0.232
TDP	0.0028	13	0.001	0.0007	0.0043
DOC	0.080	9	0.038	0.020	0.124
PP	0.0014	11	<0.001	0.0009	0.0016

Table 3. Summary of precision analysis for the project. Values are in percent relative standard deviation (% RSD) unless otherwise noted.

Analyte	Average Precision	N	Std. Dev.
Closed pH	0.01 units	54	0.04
ANC	1.01	39	2.98
Conductance	0.68	42	0.87
Chloride	0.62	33	0.77
Nitrate-N	0.86	31	0.93
Sulfate	0.68	33	0.72
Nitrite-N	<0.000 mg/L	21	<0.000
Ortho-PO4	0.001 mg/L	21	0.002
Ammonia	0.003 mg/L	21	0.010
TDN	1.74	25	1.57
TDP	2.95	33	2.60
DOC	3.30	41	3.08
PP	1.93	23	2.17
PN	3.76	32	3.33

Table 4. Natural audit sample analytical results.

Analyte	Mean	N	Std. Dev.	Minimum	Maximum
ANC	35.8	22	3.22	30.2	44.7
Conductance	28.8	17	1.13	26.3	30.7
Chloride	0.785	19	0.04	0.749	0.943
Nitrate-N	0.166	19	0.06	0.143	0.429
Sulfate	7.150	18	0.07	7.043	7.327
DOC	0.660	10	0.05	0.585	0.723

Table 5. Summary of results from 2000 NWRI interlaboratory audit.

Analyte	Rating
Conductance	Ideal
Open pH	Ideal
DOC	Ideal
ANC	Flagged high on 1 sample
Nitrate-N	Flagged low on 3 samples
Ammonia	Flagged low on 3 samples
Total Phosphorus	Ideal
Total Nitrogen	Ideal
Sulfate	Ideal
Chloride	Flagged low on 1 sample

Table 6. Summary of percent recovery results from sample spike analysis.

Analyte	Mean	N	Std. Dev.	Minimum	Maximum
Nitrite-N	104.0	28	4.0	92.9	112.6
Ortho-phosphate	101.9	28	7.2	85.6	114.0
Ammonia-N	105.5	28	4.7	94.5	115.1
Chloride	102.0	27	7.1	84.5	118.5
Nitrate-N	99.5	28	15.9	87.0	115.3
Sulfate	95.5	30	12.6	85.3	103.8
TDN	96.9	12	6.7	85.1	109.3
TDP	98.4	20	2.8	92.5	103.4
PP	102.7	16	8.6	89.1	116.7

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Environmental Protection Agency. 1987. Handbook of methods for acid deposition studies: Laboratory analysis for surface water chemistry. United States Environmental Protection Agency, Acid Deposition and Atmospheric Research Division, Office of Acid Deposition, Environmental Monitoring and Quality Assurance, Office of Research and Development, Washington, D.D. EPA-600/4-87/026.

APPENDIX C

Benthic Taxa Lists for Sites

With Duplicate Field Samples

Table C-1. Benthic taxa found in original and field duplicates. Values indicate percentage of taxon in subsample.

BRIG-307-R-2000

Taxon	Original Data	Field Duplicate
Ameletus	6.14	4.63
Amphinemura	8.77	14.81
Ancyronyx	0.88	0.00
Antocha	0.88	0.00
Baetidae	0.00	0.93
Caenis	0.88	0.00
Cheumatopsyche	2.63	0.00
Chimarra	0.88	0.00
Clinocera	1.75	1.85
Clioperla	0.88	0.00
Cricotopus/Orthocladius	1.75	0.93
Dicranota	0.00	0.93
Dicrotendipes	0.00	0.93
Drunella	0.00	1.85
Ephemerella	17.54	13.89
Eurylophella	1.75	1.85
Ferrissia	0.00	0.93
Hemerodromia	0.00	0.93
Heptageniidae	0.00	0.93
Lumbriculidae	1.75	1.85
Macronychus	0.00	0.93
Microtendipes	0.00	11.11
Nanocladius	0.00	1.85
Neophylax	3.51	1.85
Nigronia	0.00	0.93
Optioservus	0.88	0.00
Orthocladiinae A	0.00	0.93
Orthocladius	0.88	0.00
Parametriocnemus	0.00	4.63
Prosimulium	12.28	8.33
Prostoia	21.93	12.04
Psychomyia	0.88	0.00
Pycnopsyche	0.00	0.93
Rheocricotopus	0.88	0.00
Rheotanytarsus	1.75	0.00
Sphaeriidae	0.00	0.93
Stegopterna	1.75	0.00
Stenelmis	0.00	0.93
Stenonema	5.26	0.00
Stilocladius	0.00	0.93
Strophopteryx	1.75	2.78
Stylogomphus	0.88	0.00
Symposiocladius	0.00	0.93
Tanypodinae	0.00	2.78
Xylotopus	0.88	0.00

CORS-108-R-2000

Taxon	Original Data	Field Duplicate
Ablabesmyia	1.77	0.00
Acerpenna	6.19	3.85
Amphipoda	1.77	3.08
Bezzia	0.88	0.00
Caecidotea	16.81	10.77
Cheumatopsyche	1.77	3.85
Chironomini	0.00	13.85
Coenagrionidae	0.00	0.77
Conchapelopia	2.65	0.00
Diamesinae	0.00	1.54
Dubiraphia	2.65	0.00
Dytiscidae	1.77	0.00
Ephemerella	1.77	3.08
Eurylophella	4.42	5.38
Gammarus	2.65	0.00
Gomphus	0.00	0.77
Helichus	0.88	0.00
Hydropsyche	0.00	0.77
Isoperla	1.77	1.54
Leptophlebiidae	3.54	0.00
Leptophlebia	0.00	0.77
Macronychus	0.00	0.77
Microtendipes	0.88	0.00
Nanocladius	0.88	0.00
Neophylax	4.42	2.31
Nyctiophylax	0.88	0.00
Oligochaeta	0.00	4.62
Orthocladiinae	0.00	8.46
Paraleptophlebia	0.00	0.77
Paramerina	0.88	0.00
Paratendipes	1.77	0.00
Physella	0.88	1.54
Psephenus	0.00	0.77
Polypedilum	3.54	0.00
Potthastia	0.88	0.00
Prosimulium	0.88	0.00
Psephenus	1.77	0.00
Pseudolimnophila	0.88	0.00
Rheocricotopus	7.08	0.00
Sphaeriidae	7.96	13.85
Stenacron	2.65	1.54
Stenonema	4.42	0.00
Tanypodinae	0.00	6.92
Tanytarsini	0.00	7.69
Tanytarsus	2.65	0.00
Tipula	0.00	0.77
Xylotopus	0.88	0.00

CORS-102-R-2000

Taxon	Original Data	Field Duplicate
Ameletus	2.56	2.80
Amphinemura	5.13	3.74
Caecidotea	5.13	6.54
Chironomus	1.71	0.00
Conchapelopia	0.00	2.80
Corynoneura	10.26	3.74
Crangonyctidae	10.26	17.76
Cricotopus	1.71	0.00
CricotopusOrthocladius	0.00	0.93
Dytiscidae	1.71	0.00
Enchytraeidae	0.85	0.00
Heleniella	0.85	0.00
Ironoquia	0.85	0.93
Leptophlebia	0.85	1.87
Limnephilidae	0.85	0.00
Lumbriculidae	0.00	3.74
Meropelopia	0.85	0.00
Naididae	7.69	4.67
Orthocladiinae	0.00	1.87
Orthocladiinae A	0.00	0.93
Perlidae	0.00	1.87
Perlodidae	0.85	0.00
Physella	1.71	0.00
Pisidium	0.00	7.48
Polypedilum	0.85	0.00
Prosimulium	1.71	4.67
Prostoia	0.00	1.87
Pycnopsyche	0.85	0.00
Rheocricotopus	9.40	11.21
Simulium	1.71	1.87
Sphaeriidae	0.85	0.85
Stegopterna	5.13	2.80
Tanypodinae	0.00	0.93
Tanytarsus	3.42	0.00
Thienemanniella	13.68	9.35
Tubificidae	3.42	3.74
Zavrelimyia	2.56	1.87

LMON-240-T-2000

Taxon	Original Data	Field Duplicate
Acerpenna	0.82	0.00
Ameletus	3.28	3.42
Amphinemura	19.67	19.66
Centroptilum	0.00	0.85
Cheumatopsyche	0.82	0.85
Clinocera	4.10	1.71
Conchapelopia	0.82	0.85
Constempellina	1.64	0.00
Corynoneura	1.64	0.00
Crangonyx	0.82	0.85
Cricotopus/Orthocladius	5.74	0.00
Ephemerella	9.84	7.69
Eurylophella	4.92	8.55
Gomphidae	0.00	0.85
Heterotrissocladius	0.82	0.00
Ironoquia	0.82	0.00
Micropsectra	0.00	1.71
Naididae	1.64	4.27
Neophylax	4.92	4.27
Orthocladiinae	0.00	2.56
Orthocladiinae A	11.48	29.06
Parametriocnemus	2.46	0.00
Perlidae	1.64	0.00
Phaenopsectra	0.00	1.71
Polycentropus	0.00	0.85
Polypedilum	0.82	0.85
Prosimulium	4.10	2.56
Rheocricotopus	4.92	3.42
Simulium	0.82	2.56
Stenacron	0.82	0.00
Stegopterna	0.00	0.85
Tanytarsus	1.64	0.00
Trissopelopia	0.82	0.00

LOWI-113-R-2000

Taxon	Original Data	Field Duplicate
Caecidotea	96.77	83.90
Chironominae	0.81	0.00
Cricotopus/Orthocladius	0.00	0.85
Crangonyx	0.81	0.00
Lumbriculidae	0.00	0.85
Naididae	0.00	0.85
Polypedilum	0.81	0.00
Tubificidae	0.81	13.56

MATT-216-R-2000

Taxon	Original Data	Field Duplicate
Acerpenna	5.22	4.62
Baetidae	0.00	0.77
Brillia	0.87	0.00
Caecidotea	0.87	1.54
Ceratopogonidae	1.74	0.00
Cnephia	0.00	0.77
Collembola	0.00	0.77
Corynoneura	0.87	3.08
Cricotopus	5.22	3.08
Cricotopus/Orthocladius	5.55	14.62
Diplocladius	1.74	0.00
Eurylophella	15.65	7.69
Hydrobaenus	1.74	0.00
Isoperla	1.74	0.00
Leptophlebia	0.87	0.00
Micropsectra	0.00	1.54
Nemouridae	0.87	0.00
Orthocladiinae	0.87	1.54
Orthocladiinae A	5.55	10.00
Paratanytarsus	0.87	0.00
Perlidae	1.74	0.00
Polypedilum	0.00	3.85
Prosimulium	15.65	14.62
Rheocricotopus	1.74	0.00
Simulium	0.00	0.77
Siphlonurus	5.22	4.62
Stegopterna	0.00	1.54
Stempellinella	2.61	2.31
Stenelmis	14.78	10.77
Strophopteryx	0.87	0.00
Tanytarsus	3.48	1.54
Thienemanniella	4.35	9.23
Tubificidae	0.00	0.77

PATL-109-R-2000

Taxon	Original Data	Field Duplicate
Ameletus	2.63	0.93
Amphinemura	0.88	0.00
Chloroperlidae	0.88	0.00
Cricotopus/Orthocladius	15.79	0.00
Diamesa	0.00	2.78
Ephemerella	0.88	0.00
Ephemerellidae	2.63	0.93
Hemerodromia	0.88	0.00
Hexatoma	0.88	0.00
Isonychia	0.00	0.93
Lumbriculidae	0.88	0.00
Lymnaeidae	0.88	0.93
Naididae	0.00	0.93
Orthocladiinae A	0.00	16.67
Oulimnius	1.75	0.93
Parametriocnemus	0.88	0.00
Perlodidae	0.00	0.93
Prosimulium	0.88	0.00
Sympotthastia	67.54	74.07
Thienemanniella	0.88	0.00

SBPA-1O4-R-2000

Taxon	Original Data	Field Duplicate
Acerpenna	0.81	0.00
Amphinemura	14.63	9.62
Anchytarsus	0.81	0.00
Brillia	0.81	0.96
Chrysops	0.81	0.00
Clinocera	3.25	0.00
Conchapelopia	3.25	0.00
Cordulegaster	0.00	0.96
Corynoneura	4.88	0.96
Cricotopus/Orthocladius	13.82	22.12
Diamesa	0.81	1.92
Ephemerella	3.25	3.85
Eukiefferiella	0.81	0.00
Eurylophella	0.00	2.88
Gomphidae	0.81	0.00
Hydropsyche	0.00	0.96
Krenopelopia	0.00	0.96
Micropsectra	0.81	0.00
Microtendipes	0.81	0.00
Nigronia	0.00	0.96
Parametriocnemus	14.63	10.58
Potthastia	0.00	0.96
Prosimulium	17.89	24.04
Pseudolimnophila	0.00	0.96
Rheotanytarsus	0.81	0.00
Rhyacophila	0.00	0.96
Sphaeriidae	2.44	0.00
Stempellinella	0.81	0.00
Stilocladius	0.81	0.00
Sympotthastia	4.88	3.85
Tanytarsus	0.00	5.77
Thienemanniella	1.63	0.96
Tipula	0.00	0.96
Tribelos	0.81	0.00
Trissopelopia	0.81	1.92
Tvetenia	0.00	2.88
Tubificidae	3.25	0.00
Zavrelimyia	0.81	0.00

STMA-306-R-2000

Taxon	Original Data	Field Duplicate
Ablabesmyia	0.85	0.00
Acerpenna	12.82	5.30
Bezzia	0.00	0.76
Caecidotea	0.85	2.27
Cheumatopsyche	0.85	3.79
Clioperla	0.00	0.76
Conchapelopia	3.42	5.30
Corynoneura	1.71	1.52
Dubiraphia	5.98	1.52
Eukiefferiella	0.85	5.30
Eurylophella	0.00	0.76
Isoperla	41.03	16.67
Larsia	0.00	1.52
Microtendipes	0.00	0.76
Oecetis	0.00	1.52
Optioservus	0.85	0.00
Paratanytarsus	1.71	0.00
Polycentropus	0.00	0.76
Polypedilum	0.85	0.00
Probezzia	0.85	0.00
Procladius	0.00	0.76
Prosimulium	0.85	0.76
Prostoma	0.00	0.76
Rheocricotopus	5.98	3.79
Rheotanytarsus	0.00	3.03
Stenonema	14.53	16.67
Tanytarsus	4.27	15.91
Thienemanniella	0.00	1.52
Triaenodes	0.85	1.52
Trissopelopia	0.85	3.03
Unniella	0.00	2.27
Zavrelimyia	0.00	1.52

SWAN-110-R-2000

Taxon	Original Data	Field Duplicate
Acentrella	0.89	0.83
Cambaridae	0.00	0.83
Cheumatopsyche	0.89	1.67
Clinocera	6.25	3.33
Cricotopus	16.96	12.50
Cricotopus/Orthocladius	42.86	47.50
Diamesa	4.46	11.67
Diplectrona	0.00	0.83
Eukiefferiella	1.79	5.00
Hemerodromia	0.00	0.83
Orthocladiinae A	0.00	0.83
Orthocladius	1.79	0.83
Parachaetocladius	0.00	0.83
Paratanytarsus	1.79	0.00
Perlodidae	1.79	0.00
Prosimulium	8.04	10.00
Psephenus	1.79	2.50
Rheotanytarsus	0.89	0.00
Sphaeriidae	1.79	0.00
Stenelmis	0.89	0.00
Sympotthastia	0.89	0.00
Tanytarsus	2.68	0.00
Thienemanniella	3.57	0.00

UMON-134-R-2000

Taxon	Original Data	Field Duplicate
Acentrella	0.81	1.65
Ameletus	17.07	11.57
Amphinemura	13.01	14.05
Ephemerella	30.08	36.36
Heleniella	0.00	0.83
Isoperla	4.88	0.00
Naididae	6.50	1.65
Neophylax	0.00	0.83
Oemopteryx	0.00	0.83
Parametriocnemus	0.00	0.83
Perlodidae	0.00	2.48
Prosimulium	24.39	24.79
Prostoia	0.81	0.83
Rhyacophila	0.81	0.83
Stegopterna	1.63	2.48

UPCK-109-R-2000

Taxon	Original Data	Field Duplicate
Argia	0.89	0.00
Boyeria	0.89	0.00
Caecidotea	4.46	2.24
Calopteryx	0.00	1.49
Conchapelopia	0.89	0.75
Corynoneura	0.00	2.99
Crangonyctidae	0.00	1.49
Cricotopus	0.00	4.48
Cricotopus/Orthocladius	3.57	6.72
Cryptotendipes	0.00	1.49
Dubiraphia	0.89	0.75
Dytiscidae	0.00	2.24
Gammarus	55.36	39.55
Hydatophylax	0.89	0.00
Hydrobaenus	0.89	0.00
Micropsectra	0.00	2.24
Paratanytarsus	4.46	0.75
Polypedilum	10.71	11.94
Psectrocladius	0.89	0.00
Rheocricotopus	0.00	4.48
Simulium	5.36	6.72
Stenonema	2.68	1.49
Tanytarsus	5.36	2.24
Thienemanniella	0.89	5.97

WYER-118-S-2000

Taxon	Original Data	Field Duplicate
Acerpenna	0.86	1.80
Agabus	0.00	1.80
Amphipoda	9.48	23.42
Ancyronyx	0.86	0.00
Caecidotea	29.31	24.32
Cheumatopsyche	0.86	0.00
Chloroperlidae	3.45	1.80
Chrysops	0.00	2.70
Conchapelopia	0.00	0.90
Corynoneura	0.00	3.60
Cricotopus/Orthocladius	0.00	0.90
Dytiscidae	0.86	0.00
Eukiefferiella	2.59	1.80
Eurylophella	0.86	0.00
Gammarus	0.86	3.60
Goniobasis	0.00	0.90
Hexatoma	0.86	0.00
Hydrobaenus	0.00	0.90
Isoperla	13.79	3.60
Orthocladiinae	0.00	0.90
Oulimnius	0.00	1.80
Paracladopelma	0.00	0.90
Parametriocnemus	1.72	0.90
Physella	2.59	0.90
Polycentropus	0.86	0.00
Polypedilum	11.21	8.11
Potthastia	3.45	0.90
Rheocricotopus	1.72	0.90
Simuliidae	1.72	0.00
Simulium	0.00	0.90
Sphaeriidae	3.45	8.11
Stenonema	0.86	0.00
Tanytarsus	2.59	0.00
Thienemanniella	2.59	0.90
Zavrelimyia	0.00	2.70

APPENDIX D

Benthic Taxa Lists for Sites

With Duplicate Laboratory Samples

Table D-1. Benthic taxa found in original and laboratory duplicates. Values indicate percentage of taxon in subsample.

BRIG-307-R-2000

Taxon	Original Data	Laboratory Duplicate
Ameletus	6.14	6.25
Amphinemura	8.77	10.71
Ancyronyx	0.88	0.00
Antocha	0.88	0.89
Baetidae	0.00	0.89
Caenis	0.88	0.00
Cheumatopsyche	2.63	4.46
Chimarra	0.88	0.89
Chironomini	0.00	0.89
Clinocera	1.75	0.00
Clioperla	0.88	0.89
Corydalidae	0.00	0.89
Diamesinae	0.00	0.89
Empididae	0.00	2.68
Ephemerella	17.54	11.61
Eurylophella	1.75	0.89
Glossosoma	0.00	0.89
Gomphidae	0.00	0.89
Helichus	0.00	0.89
Lumbriculidae	1.75	0.00
Neophylax	3.51	0.89
Oligochaeta	0.00	3.57
Optioservus	0.88	0.00
Orthocladiinae	4.39	3.57
Prosimulium	12.28	5.36
Prostoia	21.93	25.00
Psychomyia	0.88	2.68
Stegopterna	1.75	1.79
Stenelmis	0.00	0.89
Stenonema	5.26	4.46
Strophopteryx	1.75	5.36
Stylogomphus	0.88	0.00
Tanytarsini	1.75	0.89

CORS-106-R-2000

Taxon	Original Data	Laboratory Duplicate
Amphipoda	0.00	6.84
Caecidotea	23.15	39.32
Cheumatopsyche	0.00	1.71
Chironomini	0.93	0.00
Diamesinae	0.93	0.00
Dicranota	0.93	0.85
Dubiraphia	0.93	0.00
Gammarus	25.93	10.26
Orthocladiinae	28.70	16.24
Physella	1.85	0.85
Simuliidae	0.93	2.56
Sphaeriidae	3.70	2.56
Stenelmis	0.00	0.85
Stenonema	0.93	0.85
Tanypodinae	4.63	3.42
Tanytarsini	6.48	13.68

CORS-108-R-2000

Taxon	Original Data	Laboratory Duplicate
Acerpenna	6.19	3.85
Amphipoda	1.77	3.08
Bezzia	0.88	0.00
Caecidotea	16.81	10.77
Cheumatopsyche	1.77	3.85
Chironomini	6.19	13.85
Coenagrionidae	0.00	0.77
Diamesinae	0.88	1.54
Dubiraphia	2.65	0.00
Dytiscidae	1.77	0.00
Ephemerella	1.77	3.08
Eurylophella	4.42	5.38
Gammarus	2.65	0.00
Gomphus	0.00	0.77
Helichus	0.88	0.00
Hydropsyche	0.00	0.77
Isoperla	1.77	1.54
Leptophlebia	0.00	0.77
Leptophlebiidae	3.54	0.00
Macronychus	0.00	0.77
Neophylax	4.42	2.31
Nyctiophylax	0.88	0.00
Oligochaeta	0.00	4.62
Orthocladiinae	9.73	8.46
Paraleptophlebia	0.00	0.77
Physella	0.88	1.54
Prosimulium	0.88	0.00
Psephenus	1.77	0.77
Pseudolimnophila	0.88	0.00
Sphaeriidae	7.96	13.85
Stenacron	2.65	1.54
Stenelmis	1.77	0.00
Stenonema	4.42	0.00
Tanypodinae	5.31	6.92
Tanytarsini	4.42	7.69
Tipula	0.00	0.77

CORS-205-R-2000

Taxon	Original Data	Laboratory Duplicate
Acentrella	9.48	12.20
Amphipoda	6.03	0.00
Argia	2.59	0.81
Boyeria	1.72	0.00
Caecidotea	8.62	5.69
Calopteryx	2.59	0.00
Ceratopogonidae	0.00	0.81
Cheumatopsyche	6.03	2.44
Chironomini	28.45	36.59
Corixidae	0.86	0.00
Diamesinae	1.72	0.00
Eurylophella	0.86	0.00
Gammarus	2.59	7.32
Heptageniidae	0.86	0.00
Hexagenia	1.72	0.00
Hydropsychidae	0.00	0.81
Isoperla	0.00	0.81
Lype	0.86	0.81
Macronychus	0.86	0.00
Orthocladiinae	8.62	12.20
Physella	0.86	0.81
Simulium	0.00	2.44
Sphaeriidae	1.72	0.00
Stenelmis	0.86	0.00
Stenonema	0.00	3.25
Tanypodinae	11.21	4.07
Tanytarsini	0.86	8.13
Tubificidae	0.00	0.81

LIBE-A11-R-2000

Taxon	Original Data	Laboratory Duplicate
Antocha	2.02	0.00
Cheumatopsyche	3.03	0.00
Chironominae	0.00	0.95
Chironomini	2.02	0.00
Diamesinae	2.02	0.00
Dubiraphia	1.01	0.00
Hexatoma	0.00	0.95
Hydropsyche	2.02	1.90
Lumbriculidae	0.00	1.90
Naididae	0.00	0.95
Orthocladiinae	14.14	13.33
Physella	3.03	0.95
Prosimulium	1.01	0.00
Pseudosuccinea	1.01	0.00
Simulium	0.00	2.86
Sphaeriidae	2.02	9.52
Stenelmis	1.01	1.90
Tanypodinae	13.13	6.67
Tanytarsini	52.53	58.10

LMON-239-T-2000

Taxon	Original Data	Laboratory Duplicate
Bezzia	0.00	0.79
Centroptilum	0.00	0.79
Chironomini	1.64	5.51
Crangonyx	0.00	0.79
Dugesia	0.00	2.36
Dytiscidae	0.00	0.79
Lirceus	14.75	7.09
Orthocladiinae	6.56	20.47
Simuliidae	4.10	2.36
Sphaeriidae	1.64	3.15
Tanypodinae	4.10	3.15
Tanytarsini	67.21	52.76

LOWI-102-R-2000

Taxon	Original Data	Laboratory Duplicate
Agabus	1.74	0.88
Caecidotea	40.87	38.94
Chironomini	2.61	0.88
Enochrus	0.87	0.00
Hydrobius	0.87	0.00
Ironoquia	0.87	0.88
Nemouridae	7.83	0.00
Orthocladiinae	13.91	16.81
Physella	2.61	3.54
Prostoia	0.00	2.65
Stegopterna	23.48	29.20
Synurella	3.48	6.19
Tropisternus	0.87	0.00

MATT-115-R-2000

Taxon	Original Data	Laboratory Duplicate
Caecidotea	0.95	1.05
Calopteryx	0.00	1.05
Cambaridae	1.90	2.11
Ceratopogon	12.38	4.21
Ceratopogonidae	0.95	0.00
Chironomini	12.38	6.32
Helichus	0.95	1.05
Laccophilus	0.95	1.05
Libellulidae	2.86	3.16
Oligochaeta	0.00	22.11
Orthocladiinae	9.52	8.42
Procambarus	1.90	2.11
Ptychoptera	0.95	1.05
Sialis	0.95	0.00
Synurella	26.67	1.05
Tanypodinae	15.24	29.47
Tanytarsini	0.95	13.68
Tubificidae	10.48	2.11

NANJ-119-R-2000

Taxon	Original Data	Laboratory Duplicate
Caecidotea	0.87	1.57
Chironomini	0.87	0.00
Diplectrona	10.43	13.39
Eccoptura	3.48	0.00
Eurylophella	0.87	0.00
Gomphidae	0.87	0.00
Hexatoma	0.87	0.00
Isotomurus	0.87	0.00
Leuctra	15.65	9.45
Lumbriculidae	3.48	0.00
Lype	0.00	0.79
Nigronia	2.61	2.36
Oligochaeta	0.00	3.15
Orthocladiinae	6.09	7.87
Oulimnius	0.87	0.00
Polycentropus	0.00	1.57
Prosimulium	0.87	1.57
Sialis	0.87	1.57
Simulium	4.35	8.66
Stegopterna	41.74	40.16
Stenelmis	0.00	0.79
Synurella	0.87	0.00
Tanypodinae	1.74	3.94
Tanytarsini	1.74	3.15

NASS-301-S-2000

Taxon	Original Data	Laboratory Duplicate
Amphipoda	1.82	0.00
Caecidotea	26.36	21.05
Chironomini	3.64	0.88
Cnephia	6.36	2.63
Corixidae	0.00	0.88
Crangonyctidae	0.91	2.63
Diamesinae	0.91	0.00
Ferrissia	0.00	1.75
Glossiphoniidae	0.00	0.88
Heptageniidae	0.00	0.88
Hydroporus	0.00	1.75
Leptophlebiidae	5.45	5.26
Menetus	0.91	1.75
Oligochaeta	0.00	2.63
Orthocladiinae	2.73	0.88
Perlesta	14.55	7.02
Physella	1.82	3.51
Prostoia	0.91	2.63
Pseudosuccinea	0.00	0.88
Simulium	4.55	0.88
Sphaeriidae	0.00	4.39
Sphaerium	1.82	0.00
Tanypodinae	21.82	26.32
Tanytarsini	4.55	10.53
Triaenodes	0.91	0.00

PAXL-294-S-2000

Taxon	Original Data	Laboratory Duplicate
Acentrella	42.07	37.25
Acerpenna	8.97	5.88
Amphinemura	0.69	0.98
Anchytarsus	0.69	0.00
Caecidotea	2.76	0.00
Chloroperlidae	2.76	3.92
Cordulegaster	0.69	0.98
Crangonyctidae	3.45	0.98
Culicoides	0.00	0.98
Dicranota	0.00	0.98
Ephemerella	24.83	25.49
Eurylophella	0.69	0.00
Gordiidae	0.00	0.98
Helichus	0.69	0.00
Isoperla	0.69	0.00
Leuctra	0.69	0.00
Limnephilidae	0.69	0.00
Naididae	0.69	0.00
Optioservus	0.69	0.98
Orconectes	0.00	0.98
Orthocladiinae	1.38	3.92
Oulimnius	0.00	1.96
Perlesta	0.69	0.00
Perlidae	1.38	4.90
Probezzia	0.00	0.98
Simulium	3.45	5.88
Stenonema	0.69	0.00
Taeniopteryx	0.00	0.98
Tanypodinae	0.00	0.98
Tipula	0.69	0.00

SEAS-120-R-2000

Taxon	Original Data	Laboratory Duplicate
Aedes	9.65	5.13
Agabus	7.89	3.42
Amphipoda	7.02	9.40
Caecidotea	11.40	8.55
Chironomini	4.39	2.56
Diamesinae	0.00	1.71
Dolichopodidae	0.88	0.85
Dugesia	0.88	0.85
Dytiscidae	0.88	0.00
Hydrobius	0.88	3.42
Isotomurus	9.65	4.27
Macronychus	0.00	0.85
Menetus	0.88	0.00
Microvelia	0.00	0.85
Oligochaeta	0.00	41.88
Orthocladiinae	4.39	0.85
Physella	7.89	4.27
Sphaeriidae	4.39	5.13
Synurella	0.88	1.71
Tanypodinae	0.00	0.85
Tanytarsini	0.00	3.42
Tubificidae	28.07	0.00

TOWN-408-R-2000

Taxon	Original Data	Laboratory Duplicate
Acentrella	0.91	0.96
Amphinemura	10.00	9.62
Caenis	2.73	4.81
Chelifera	0.00	0.96
Chimarra	5.45	6.73
Chironomini	2.73	0.00
Chloroperlidae	1.82	0.00
Clinocera	1.82	6.73
Dolophilodes	2.73	0.96
Drunella	4.55	3.85
Dubiraphia	0.91	0.00
Ectopria	0.00	0.96
Ephemerella	0.00	1.92
Eurylophella	0.91	0.00
Glossosomatidae	1.82	0.00
Heptageniidae	0.00	0.96
Isonychia	10.91	9.62
Leptophlebiidae	0.91	0.00
Leptoxis	2.73	0.96
Leuctridae	0.91	0.96
Lumbriculidae	6.36	10.58
Muscidae	0.91	0.00
Naididae	1.82	0.00
Nemouridae	0.91	0.00
Orthocladiinae	7.27	7.69
Orthotrichia	0.91	0.00
Perlodidae	0.91	1.92
Physella	0.00	0.96
Prosimulium	1.82	2.88
Serratella	6.36	13.46
Simulium	17.27	10.58
Stenonema	1.82	0.00
Tanytarsini	1.82	0.00
Tipula	0.00	1.92

UMON-131-R-2000

Taxon	Original Data	Laboratory Duplicate
Agabus	1.87	0.00
Cnephia	0.93	0.85
Cura	8.41	5.93
Enchytraeidae	4.67	0.00
Limnephilidae	0.00	0.85
Oligochaeta	0.00	8.47
Orthocladiinae	37.38	54.24
Physella	12.15	5.08
Planorbella	0.00	0.85
Probezzia	0.00	1.69
Prosimulium	2.80	2.54
Stegopterna	22.43	13.56
Tanypodinae	6.54	2.54
Tanytarsini	0.00	3.39
Tanytarsus	2.80	0.00

UPCK-203-R-2000

Taxon	Original Data	Laboratory Duplicate
Acentrella	0.00	0.86
Agabus	0.97	0.86
Amphinemura	13.59	17.24
Amphipoda	0.00	6.90
Anchytarsus	0.00	0.86
Ancyronyx	0.97	0.00
Baetidae	0.00	0.86
Caecidotea	0.97	0.86
Caenis	0.97	0.00
Chironomini	2.91	0.00
Coenagrionidae	0.97	0.00
Calopteryx	0.00	0.86
Dolophilodes	0.00	0.86
Dubiraphia	0.97	0.86
Dytiscidae	0.97	1.72
Eurylophella	1.94	0.00
Helichus	3.88	0.86
Heptageniidae	0.00	1.72
Isoperla	9.71	8.62
Orthocladiinae	12.62	12.07
Paraleptophlebia	0.97	0.00
Perlidae	0.97	2.59
Phryganeidae	0.97	0.00
Physella	1.94	0.86
Prosimulium	33.01	24.14
Rhyacophila	0.00	0.86
Simulium	5.83	4.31
Somatochlora	0.00	0.86
Sphaeriidae	0.00	0.86
Stenelmis	0.00	1.72
Stenonema	0.97	0.00
Tanypodinae	0.97	5.17
Tanytarsini	2.91	2.59

WIRH-220-S-2000

Taxon	Original Data	Lab Duplicate
Acentrella	2.61	0.00
Amphipoda	6.09	0.00
Caecidotea	1.74	3.64
Chironomini	16.52	0.00
Ephydridae	0.87	0.00
Eurylophella	15.65	9.09
Gammarus	0.87	23.64
Hydroporus	0.87	0.00
Isoperla	2.61	10.91
Leptophlebiidae	0.87	0.00
Macronychus	0.00	10.91
Nigronia	0.87	0.00
Macronychus	0.00	1.82
Orthocladiinae	12.17	0.00
Simulium	17.39	40.00
Stenonema	4.35	0.00
Tanypodinae	2.61	0.00
Tanytarsini	13.04	0.00
Triaenodes	0.87	0.00

APPENDIX E

Number of Individual Fish Species Sampled

Compared to Number Retained As Fish Voucher Specimens

Table E-1. Number of individual fish sampled compared to number retained as voucher specimens by 6-digit watershed.

6-digit Watershed	Species	# Sampled	# Vouchered
Bush River	Cutlips Minnow	26	4
	RedBreast Sunfish	21	1
	Tessellated Darter	156	8
Chester River	Pumpkinseed	17	5
	Redbreast Sunfish	10	8
	White Sucker	36	3
Choptank River	Bluespotted Sunfish	7	0
	Brown Bullhead	20	2
	Chain Pickerel	10	5
	Fallfish	1	0
	Green Sunfish	1	0
	Largemouth Bass	24	5
	Least Brook Lamprey	139	6
	Mosquitofish	1	0
	Pumpkinseed	35	0
	Tessellated Darter	792	8
	Yellow Bullhead	8	4
Gunpowder River	Brook Trout	60	4
	Fantail Darter	116	9
	Green Sunfish	8	6
	Northern Hogsucker	7	6
	White Sucker	156	8
Lower Potomac River	Bluegill	704	2
	Bluespotted Sunfish	19	8
	Brown Bullhead	20	9
	Chain Pickerel	30	2
	Golden Shiner	82	1
	Green Sunfish	5	2
	Largemouth Bass	9	5
	Least Brook Lamprey	441	7
	Margined Madtom	20	4
	Pumpkinseed	95	4
	Redbreast Sunfish	83	2
	Redfin Pickerel	11	0
	Sea Lamprey	25	5
	Swallowtail Shiner	2	0
	White Sucker	8	0
	Yellow Bullhead	15	0

Table E-1. (Continued)			
6-digit Watershed	Species	# Sampled	# Vouchered
Middle Potomac River	Brook Trout	19	0
	Brown Bullhead	2	1
	Brown Trout	49	9
	Common Shiner	3	1
	Creek Chub	263	0
	Creek Chubsucker	4	3
	Unknown Cyprinid	1	0
	Fallfish	10	7
	Green Sunfish	434	6
	Longear Sunfish	1	0
	Longnose Dace	379	0
	Margined Madtom	1	0
	Northern Hogsucker	23	0
	Redbreast Sunfish	70	9
	Rock Bass	12	5
	Smallmouth Bass	16	6
	Yellow Bullhead	15	6
Nanticoke River	American Eel	92	9
	Chain Pickerel	36	7
	Golden Shiner	1	0
	Largemouth Bass	9	3
	Mosquitofish	10	8
	Pirate Perch	264	9
	Redfin Pickerel	7	5
Patapsco River	American Eel	96	0
	Blacknose Dace	5701	2
	Bluegill	246	5
	Bluntnose Minnow	2249	9
	Brook Trout	18	0
	Brown Trout	65	7
	Creek Chub	954	1
	Fallfish	10	0
	Fathead Minnow	13	1
	Golden Shiner	25	1
	Green Sunfish	75	6
	Largemouth Bass	55	6
	Lepomis hybrid	6	5
	Margined Madtom	17	0
	Mosquitofish	8	0
	Pumpkinseed	15	0
	Rainbow Trout	2	0
	Rosyface Shiner	1	0
	Smallmouth Bass	10	6
	Spottail Shiner	14	0
	Swallowtail Shiner	188	0
	Yellow Bullhead	3	0

Table E-1. (Continued)

6-digit Watershed	Species	# Sampled	# Vouchered
Patuxent River	Brown Bullhead	26	2
	Eastern Mudminnow	22	2
	Fathead Minnow	20	9
	Golden Shiner	6	0
	Largemouth Bass	114	9
	Lepomis hybrid	1	0
	Pumpkinseed	60	2
	Rainbow Trout	5	0
	Redfin Pickerel	1	0
	Spottail Shiner	25	0
	Yellow Bullhead	72	1
Upper Potomac River	Blacknose Dace	1940	5
	Bluegill	8	0
	Brown Trout	1	0
	Chain Pickerel	5	2
	Creek Chub	572	0
	Cutlips Minnow	44	3
	Golden Redhorse	3	2
	Goldfish	4	0
	Largemouth Bass	6	1
	Northern Hogsucker	32	9
	Potomac Sculpin	366	0
	Pumpkinseed	10	0
	Rainbow Darter	811	1
	Rock Bass	217	7
	Smallmouth Bass	179	9
	Tessellated Darter	10	9
	White Sucker	75	6
Youghiogheny River	Blacknose Dace	229	0
	Bluegill	13	0
	Bluntonose Minnow	26	0
	Brook Trout	20	0
	Brown Bullhead	26	0
	Common Shiner	3	0
	Creek Chub	805	0
	Golden Shiner	17	0
	Johnny Darter	68	0
	Mottled Sculpin	697	0
	Northern Hogsucker	32	0
	Pumpkinseed	35	0
	River Chub	9	0
	Rock Bass	48	0
	Smallmouth Bass	1	0
	Striped Shiner	1	0
	White Sucker	22	0